U. S. DEPARTMENT OF AGRICULTURE.

REPORT

OF THE

CHIEF OF THE DIVISION OF CHEMISTRY

FOR

1891.

BY

H. W. WILEY.

FROM THE REPORT OF THE SECRETARY OF AGRICULTURE FOR 1891.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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REPORT OF THE CHEMIST.

SIR : I beg leave to submit herewith an abstract of the work of the Division of Chemistry during the year 1891.

Respectfully,

H. W. WILEY,
Chemist.

Hon. J. M. RUSK,
Secretary.

THE USE OF ALCOHOL IN THE MANUFACTURE OF SUGAR FROM SORGHUM.

To enable the Department to make a practical test of the method outlined last year for the use of alcohol in the manufacture of sugar, a grant of $25,000 was made by Congress. Medicine Lodge, Kans., was selected as the place for making these experiments. The climatic conditions of this place, as indicated by three years' experience, are favorable to the production of sorghum with a high content of sugar. The town is situated at the terminus of a branch of the Atchison, Topeka and Santa Fé Railroad, in Barber County, Kans., 340 miles southwest from Kansas City, and about 20 miles from the Indian Territory line. The prevailing soil is a reddish loam, very fertile, and producing large crops of all kinds of cereals when sufficient rain is supplied. The field for growing the cane for experimental purposes was leased from Miller & Benedict, and contains 39½ acres. It is situated on the north bank of Medicine River, 2 miles west of the village. The surface is practically level, being, however, slightly higher on the north side, affording excellent natural drainage in case of heavy storms of rain.

The field was platted by the county surveyor into sixteen blocks, each separated by an alley 10 feet in width. Eight of the blocks on the south side contain each 80,000 square feet. Of the remainder, seven in the north part of the field contain exactly 2 acres each, and the last one, in the extreme north end, 3 acres. The field was plowed in April to a depth of 8 or 9 inches, and the south half of it subsoiled to the depth of 6 inches. Planting commenced in the latter part of April and was nearly all completed by the 1st of May.

The seed from which the planting was made had been grown at the Department Experiment Station, at Sterling, during the season of 1890. The following varieties were planted: Early Amber, Folger's Early, Early Orange, Black African, Link's Hybrid, Undendebule No. 1, Australian, Variety 161, Variety 160, Colman, Variety 91, Variety 112, Alapore Jowar, Planter's Friend, India and Orange, Ubehlana.

The field received careful culture, and the season, on the whole, was favorable. The subsoiling enabled the crop to bear, without any injury whatever, the severe drought beginning in July and extending through the greater part of August. Beginning on the 14th of September, and continuing for three days, a sample was taken from each of the varieties grown, representing an aliquot part of an acre. The total weight of this sample was determined and likewise the weight of the seed tops and

leaves, giving, by difference, the weight of clean cane. Afterwards the seeds were thrashed and weighed.

The results, showing weight of whole cane, weight of blades and trash, weight of clean cane, and weight of dry seed, are given in the following table:

Per acre.

Variety.	Weight, whole cane.	Weight, blades and trash.	Weight, clean cane.	Weight of dry seed.
	Tons.	*Tons.*	*Tons.*	*Pounds.*
Folger's Early	13.96	1.67	10.07	2,340
Colman Cane	12.08	1.66	8.09	(*)
Link's Hybrid	10.72	1.26	7.67	(*)
Black African	13.17	1.48	9.17	1,093
Early Orange	14.54	1.64	9.86	1,937
Undendebule No. 1	16.36	1.88	11.48	1,304
Colman Cane (*bis.*)	14.78	1.68	11.51	2,384
Australian	11.69	0.97	8.61	1,768
No. 161	15.04	1.77	10.89	1,904
No. 160	11.06	1.03	8.38	1,196
No. 91	14.33	1.76	10.19	2,558
No. 126	10.01	1.39	7.01	1,166
No. 112	13.28	1.76	9.53	2,558
Planter's Friend	14.58	2.12	10.60	1,180
India and Orange	13.80	1.86	9.56	2,099
Ubehlana	13.65	1.65	9.77	1,399

*Not taken.

Concerning the two samples of Colman cane mentioned in the above table, they were taken from two different plats representing different parts of the field. The seed from the first plat was not saved. By some oversight the seed from the Link's Hybrid was also lost. In regard to the sample of Link's Hybrid, it is but fair to say that it was taken from a single row and not from the block which was planted in Link's Hybrid. The showing, therefore, is not fair, inasmuch as the plat of Link's Hybrid was fully equal, as far as appearance goes, to any other cane in the field.

The selections mentioned above extended from the 14th of September to the 19th, thus giving a comparison of all the varieties at the time when the earliest were quite ripe and the latest nearly so. The chief object of taking the samples at the time was to determine the comparative yield of all the varieties while they were still green and before frost had affected them. Nevertheless, it was decided also to determine the quantity of sugar in the juice of each variety.

The percentage of sugar in the juice, the number of stalks per acre, and the yield in sugar per acre, of each variety follow:

Variety.	Sugar in juice.	Number stalks per acre.	Sugar per acre.
	Per cent.		*Pounds.*
Folger's Early	15.75	(*)	2,745
Colman Cane	14.50	14,022	2,071
Link's Hybrid	13.10	11,434	1,758
Black African	12.95	15,253	2,090
Early Orange	10.20	17,533	1,767
Undendebule No. 1	13.75	24,339	3,021
Colman Cane (*bis.*)	14.10	20,935	2,670
Australian	14.55	11,147	2,104
No. 161	9.40	24,168	1,805
No. 160	12.10	15,561	1,995
No. 91	12.45	18,095	2,237
No. 126	16.25	13,959	2,294
No. 112	14.15	19,874	2,369
Planter's Friend	14.35	18,622	1,870
India and Orange	12.25	15,785	2,059
Ubehlana	12.00	17,392	2,090

*Not given.

From average determinations, which have been repeatedly made, it is found that the amount of sugar in the cane is about 88 per cent of that in the juice. The numbers in the above table, therefore, multiplied by 0.88, will give the actual quantity of sugar in the cane.

The column giving the number of stalks per acre is also interesting. In the case of Link's Hybrid, as has before been mentioned, there was a poor stand in the row which was taken for illustration, and this row shows the lowest number of stalks per acre. It will require longer experience to decide the point in regard to the proper number of plants per acre, and this number will doubtless vary for the different varieties of cane.

The Undendebule variety is a slender stalk with a small seed head, and would doubtless be able to carry more stalks per acre than the Early Orange or the Colman; nevertheless, it seems quite evident that in many instances a larger number of stalks could have been grown per acre without materially lessening the average weight of each stalk, or interfering with its content of sugar From present indications it may be said that there should not be less than 20,000 stalks per acre.

The yield of seed is also most gratifying. At 50 pounds per bushel many of the varieties have yielded over 40 bushels per acre, and, in one or two instances, 50 bushels, the lowest yield being slightly over 20 bushels per acre. The value, therefore, of sorghum as a cereal crop should not be without consideration, inasmuch as the food value of sorghum seed is almost if not quite equal to that of maize. When the greater certainty of the crop is considered, especially when grown in the semiarid regions, its value as a food crop is certainly equal to that of maize. There is, of course, but little demand for sorghum seed as a food supply at the present time, but its growth in large quantities would doubtless create a market in which it would find a profitable sale.

The column showing the yield of sugar per acre indicates, of course, the total sugar grown and not the amount which could be recovered. Up to the present season the recovery of 33 per cent of the total sugar in the sorghum crop has been regarded as a good manufacturing yield. Thus the actual yield per acre of commercial sugar would be one-third of the quantity given in the table. By improved processes of manufacture, however, the rate of yield has been raised to 60 per cent and even 65 per cent, and there is little doubt of the fact that it can, within a year or two, be made to reach 70 per cent. The actual quantity of sugar, therefore, which it may now be said can be obtained per acre would be two-thirds of the quantity given in the table. In some instances it is seen that this would amount to fully 1 ton of sugar per acre. At 2½ cents a pound, a ton of sugar would be worth $50, and this must be regarded as a very satisfactory financial return when the other elements of the crop are taken into consideration.

MANUFACTURING PART.

As explained in the report of last year, alcohol of 95 per cent strength is found to precipitate almost completely certain gummy and amorphous substances present in sirup made from sorghum containing from 50 to 55 per cent of solid matter, or, as is commonly said, sirup of from 50° to 55° Brix. For the purpose of testing this process in a commercial way, a small experimental factory was built at Medicine Lodge, Kans. The contract for building this factory was let to the Fort Scott Foundry and Machine Works Company. Preliminary trials were made

of the machinery early in September, but many defects had to be corrected before actual work could begin. The necessary changes and alterations in the machinery occupied the time fully until early in October. The capacity of the house was calculated so as to be able to work 1 ton of cane per hour. The actual capacity, however, was found to be greater than this, and, after all the adjustments were made, it was found that 1½ tons per hour could be easily handled. In addition to the ordinary machinery for manufacturing sugar, there was erected, in connection with the establishment, a still for the purpose of recovering the alcohol used in precipitating the gummy and amorphous substances from the sirup. This still was built by Klingel Bros., of Peoria, Ill. It was 2 feet in diameter, 25 feet high, and had a capacity of furnishing 1,000 gallons of 95 per cent alcohol per day.

The method of treating the cane was as follows:

It was first cut into pieces 1 inch in length by an ensilage cutter. These pieces were next passed through a fanning apparatus for the purpose of removing the leaves and trash. The clean pieces of cane then passed to a shredding machine, in which they were cut into very small pieces, almost a pulp. The pulp passed next to the diffusion battery, where the sugar was extracted. The diffusion juice was collected in clarifying tanks, treated with lime, and the skimmings removed. Instead of sending the skimmings through a filter press, as would be ordinarily done in a sugar factory, on account of their small quantity they were collected in a separate tank and reclarified, only the heavy scums and sediment being thrown away. The juice, after clarifying, was concentrated to sirup in a triple-effect evaporating apparatus. The density of this sirup was made to register 50° to 55° Brix. The sirups were collected in precipitating tanks, in which they were treated with an equal volume of 95 per cent alcohol and thoroughly mixed. The precipitated gums were separated by passing through a filter press, forming, for the most part, hard firm cakes containing only a small quantity of alcohol and sugar. The filtered sirup was next passed through the still for the purpose of recovering the alcohol. As soon as the alcohol was separated the sirup was boiled to sugar in a vacuum strike pan and dried in a centrifugal. No attempt was made to make refined sugar, only raw sugar being made.

Considering the fact that it was the first attempt ever made at work of this kind, it must be admitted that the apparatus worked smoothly and effectually, although many points were noticed where improvements could be made in details.

A summary of the results obtained with some of the varieties worked follows:

Colman Cane.—22.44 tons of Colman cane were delivered from the field, representing 17.47 tons of clean cane. The sirup was divided into two portions: the first portion boiled without treatment with alcohol, marked *a*, and the second portion boiled after treatment with alcohol, marked *b*. The first portion yielded 1,370 pounds of first sugar and 375 pounds of second sugar, being 156.8 pounds of first sugar and 199.7 pounds of first and second sugar per ton. The second part treated with alcohol yielded 1,330 pounds of first sugar, equivalent to 152.3 pounds per ton. The amount of second sugar was not determined. Apparently, from the above data, the untreated portion—that is, the portion treated by the ordinary process—yielded more sugar than that treated with alcohol, but this is only in appearance. The sirup boiled without treatment it was found could not be passed through the centrifugals although it was grained in the pan. The pan, however, being small, the grain was very fine, and this, combined with the gums, etc., present, made it impossible to pass it through the centrifugals. It was therefore placed in the hot room and allowed to stand a long while before being dried. The sugar obtained was of low polarization. On the other hand, the part which was treated with alcohol grained beautifully in the pan and was carried directly to the centrifugal, where it was dried in a very few

minutes, working as nicely in the machine as any massecuite could possibly have done from sugar cane grown in Louisiana or Cuba. There is, however, a considerable loss of sugar in the filter presses and in the still, which could not possibly be avoided in working in a small way. In addition to this the sirup boiled so freely in the pan that a considerable part was projected into the throat and carried over by entrainment. This was not the case with the sugar boiled in the ordinary way, which was sticky and was not projected into the throat of the pan. Calculated to pure sugar, the amounts of first sugar yielded by the two portions were: *a* portion, 132 pounds per ton; *b* portion, 142.7 pounds per ton. The percentage of sugar in the cane obtained as merchantable sugar, on the first portion, was 65.52. Unfortunately, in boiling for seconds from the alcohol portion, the proof was allowed to become too dense, and the result was that the massecuite was almost in the form of taffy. On account of this the sugar did not separate, and no seconds were made from the alcohol run.

The above rather minute description has been given of the run with the Colman cane, inasmuch as it represents the best cane worked, and the results are the most favorable.

Early Orange.—8.65 tons of Early Orange were worked, both by the *a* and *b* methods. The yield by the *a* method was 138.9 pounds of raw sugar, representing 54.93 per cent of the sugar in the cane. The yield by the alcohol method was 156 pounds of raw sugar, representing 67.70 per cent of the sugar in the cane. Calculated to pure sugar, the yield by the *a* method was 118.6 pounds per ton and by the alcohol method 146.2 pounds per ton.

Link's Hybrid.—9.77 tons of Link's Hybrid were worked by each of the methods given. Method *a* yielded 140.6 pounds of raw sugar, equivalent to 116 pounds of pure sugar per ton; worked by the alcohol method the yield was 148.7 pounds of raw sugar, equivalent to 139.6 pounds of pure sugar per ton. By the *a* method, the sugar recovered was 47.69 per cent of the sugar in the cane; by the *b* method, 61.47 per cent of the sugar in the cane.

Undendebule.—8.66 tons of Undendebule were worked by each of the methods. Method *a* gave 105.7 pounds of raw sugar, equivalent to 93 pounds of pure sugar per ton, equal to 35.18 per cent of the sugar in the cane. Worked by the *b* method the yield was 151.2 pounds of raw sugar, equivalent to 133.4 pounds of pure sugar per ton, or 50.45 per cent of sugar in the cane.

Varieties 112 and 91.—9.28 tons of the mixed varieties were worked by each of the methods. By the *a* method the yield was 130.5 pounds of raw sugar, equivalent to 107.5 pounds of pure sugar per ton, or 47.73 per cent of the sugar in the cane. Worked by the *b* method the yield was 140.3 pounds of raw sugar, equivalent to 131.3 pounds of pure sugar per ton, or 58.30 per cent of the sugar in the cane.

These results are all given on the yield of first sugars alone. In every case it was found impossible to dry the first sugars made by the *a* method until after they had stood for some time in the hot room; while in every case the sugars made by the alcohol method were passed at once through the centrifugal, yielding a fine grade of raw sugar.

In spite of the constant losses attending the alcohol method, which are easily avoided in working in a large way, it is found that the yield of sugar is uniformly very much higher, amounting to from 15 per cent to 20 per cent on the total sugar in the cane. In addition to this, however, it should be stated that the ease with which this sugar is worked would probably compensate for the increased cost, even if no more sugar per ton were made. In many cases it was possible to dry a full charge of sugar in two or three minutes instead of having to run the centrifugal for half an hour, as is usually the case with sugar worked in the ordinary way. The loss of alcohol was extremely small, none of it being found in the sugar, and the only loss being in the filter presses, where, of course, a small loss is unavoidable.

In general, it may be said that the results were satisfactory, although the work revealed many points where improvements could be made to render it more effectual and economical. Full details of the manufacturing operations will be found in Bulletin No. 32.

CULTURE EXPERIMENTS WITH SORGHUM AT STERLING.

The culture experiments of former years were continued at Sterling during the year 1891, with the same general purpose and methods. Quite a number of small plats of land were leased and planted with varieties, the selection of the growth of 1890. Six hundred plats were planted with seed grown in 1890; 31 plats were planted with seed received from foreign countries; 33 plats, containing nearly one acre each, were planted with varieties which had given best results in previous years. The object of planting these large plats was to get an average value of each, and to supply an ample quantity of seed of the best varieties for distribution. Seventy-two plats were planted in crosses of those grown in former years and considered worthy of further trial.

It was noticed that on clayey soil the cane did remarkably well in wet weather, but did not stand the drought well; while those varieties planted on sandy soil remained vigorous during August and September, which were dry months; June and July, on the contrary, being very wet for Kansas.

There are from 20,000 to 30,000 seeds in a pound of sorghum. Two pounds per acre, therefore, ought to give a very vigorous stand. About 2 pounds were used in planting the plats at Sterling. It has been observed that canes which are too close together suffer most from drought, while an increased tonnage is not secured by the thick planting. In general, it may be said of the crop at Sterling that the tonnage was large and the average quality of the juice good, but the season of maturing was somewhat delayed.

In all, 2,672 analyses of sorghum juice were made at the station, and for seed selection 26,635 polarizations of the juice from single canes were made. These 26,635 samples were selected from about 100,000 canes that were ground separately, but three-fourths of the number ground were rejected on account of showing low specific gravity. In all, 26,635 seed heads were selected as the result of the first polarization. From this number 7,827 were taken whose juice had a mean value of 15.98 per cent sucrose, with a purity of 73.78. From these a fourth selection was made of 1,768, whose juice had a mean value of 16.41 sucrose and 76.84 purity. Of the whole number of 26,635 selections, 5,905 contained between 15 and 16 per cent of sucrose, 5,296 contained between 16 per cent and 17 per cent, 2,550 contained between 17 per cent and 18 per cent, 172 contained between 18 per cent and 19 per cent, and 23 had 19 per cent and over. In general, the largest canes of the best varieties were selected in the field, and the small canes were thrown out by a second selection at the mill. In this way selections of seed were made, first from the best varieties, second from the largest canes, and in the third place from those which showed the highest percentage of sugar and high purity.

The varieties which have shown the best results at the Sterling Station, in the order named, are: (1) Australian (McLean); (2) Undendebule (Collier); (3) Colman; (4) Planter's Friend; (5) Folger's Cane. It must be remembered, however, that they are based solely upon analysis and not upon actual working in the sugarhouse.

The results of four years' experimental work would tend to show that sorghum is as stable in quality as other plants are; that the varieties have definite qualities of juice, which may be regarded as belonging to them and which are characteristic of them; and that the best

varieties, under climatic conditions similar to those of this station, with good cultivation, will yield canes which will have on an average 14 per cent of sugar in the juice, or a little over 12 per cent in the cane itself, producing about 240 pounds of sugar to the ton.

As was shown at Medicine Lodge, it is possible now to get 65 per cent of the sugar in the cane, which would give a yield, with such cane as indicated, of 156 pounds per ton.

Early Amber.—The mean composition of this cane for four years is as follows: Sucrose, 11.36 per cent; reducing sugar, 1.70 per cent, with a purity of 68.78.

Australian Cane.—This cane it is proposed to call McLean, on account of having been received from Hon. Peter McLean, undersecretary of agriculture of Queensland, in 1890. It has given the best results of any other variety for the two years in which it has been grown. It matures rather early, and will, perhaps, be suitable for growing a little farther north than most others. The canes are tall and rather slender, but withstand the winds as well as any of the varieties noted. The mean value for the two years of this variety is: Sucrose, 15.30 per cent; glucose, 0.62 per cent, with a purity of 75.09.

Colman Cane.—The mean value of Colman cane for three years shows 14.24 per cent sucrose, 1.05 per cent glucose, with a purity of 75.05.

Collier Cane.—The seed of this cane was furnished the station by Dr. Peter Collier, of Geneva, N. Y., under the name of Undendebule No. 1. In recognition of the great service of Dr. Collier to the sorghum-sugar industry it is proposed to call it by his name. The mean value of this cane for four years shows 14.29 per cent sucrose, 0.72 per cent glucose, with a purity of 72.90.

Folger's Cane.—The mean value of this cane for three years shows 13.50 per cent sucrose, 1.84 per cent glucose, with a purity of 73.60.

Planter's Friend.—The mean value of this cane for four years shows 14.45 per cent sucrose, 1.31 per cent glucose, with a purity of 73.54.

Variety No. 112.—The mean value of this variety for three years shows 14.06 per cent sucrose, 0.99 per cent glucose, with a purity of 74.51.

Variety No. 161.—The mean value of this variety for three years shows 13.40 per cent sucrose, 0.66 per cent glucose, and 74.83 purity.

Early Orange.—The mean value of this cane for four years shows 12.17 per cent sucrose, 2.34 per cent glucose, with a purity of 68.08.

Detailed information in regard to further work at the Sterling Station will be found in Bulletin No. 32.

The importance of the work at this station can scarcely be estimated in relation to practical results in the manufacture of sugar from sorghum. It appears that by the systematic methods of selecting varieties it is possible to develop qualities in sorghum cane which will permit of its taking its place in the same rank with sugar cane and sugar beets as a source of the sugar supply of the world. The remarkable progress which has been made for four years is a sufficient justification for the continuance of the work in practically the same lines of investigation. It would not be reasonable to expect a continuance of the rapid improvement in the quality of the cane which the first four years of the work has shown. The chief expectation of the future must be in establishing firmly the good qualities of the different varieties, and in the gradual but slow improvement of these qualities.

It seems at the present time that little would be required in addition to the production of cane as rich in sugar-producing qualities as some of those which have been grown at the Sterling Station, but these qualities must be so well established as to enable the planter to depend

upon them from year to year for field culture. That much has been done in this direction is shown by the results at the Medicine Lodge Station during the present year, where large plats of cane showed the same good qualities in the factory which they had previously disclosed in the laboratory.

EXPERIMENTS WITH SUGAR BEETS.

For the purpose of promoting the culture of sugar beets, looking to the manufacture of sugar, an experiment station was established in the State of Nebraska, at Schuyler. Thirty acres of land were leased in the early winter and prepared for planting in the spring. The intention of taking so large a field was to permit the practice of systematic rotation with the object of having the same plat of land in beets only once in four years. This would give 7½ acres for the planting of each year. The experimental field is located near the junction of the Shell Creek Valley with the Platte River Valley. It is about 6 miles north of the Platte River, and is protected on the north and west by a range of hills about 50 feet high. The soil of the field is a dark loam about 2½ feet in depth. This rests upon about 1½ feet of clay and sand, gradually merging into a fine sand to a depth of about 5 feet. It is a loose porous soil of excellent quality.

The field selected for the beets had not been in previous cultivation, but had been used as a pasture for many years. A field which had been previously tilled would have been preferred for the purposes of our work, but it was found difficult to get such a field in a suitable location. For the purpose, however, of testing soil previously cultivated, a part of the planting was made in a different field which had been several years in cultivation, but with a northern instead of a southern exposure.

The seed bed was prepared as early in the spring as the weather would permit, by plowing to the depth of 8 or 9 inches and subsoiling to the depth of 5 or 6 inches. The surface of the soil was placed in proper tilth by harrowing and rolling, and the field was ready for planting in the latter part of April and the 1st of May.

The north field was planted beginning on the 29th of April. The seed was put in with a drill from 1 inch to 1½ inches in depth. The seed was planted in rows 17 inches apart, and at the rate of 15 to 20 pounds per acre. After planting the ground was rolled. Six varieties were planted, viz: (1) Klein Wanzlebener, furnished by Dippe Bros., of Quedlinburg; (2) White Improved, furnished by Vilmorin & Co., Paris; (3) Desprez variety; (4) Variety from Lemaire; (5) Variety furnished by Knauer; (6) Klein Wanzlebener Elite.

The plats in the south field, viz, the regular station field, were planted on the 5th and 6th of May. The whole month of May remained quite dry, and the seeds germinated poorly. Rains in June, however, brought the beets on rapidly and necessitated thinning, which was completed in all the plats by June 18.

The cultivation of the beets consisted simply in keeping the surface of the ground in good tilth and preventing the growth of weeds. It was accomplished jointly by horse and hand hoes. A good stand of beets was secured on all the plats, and the months of June and July were especially favorable to a rapid and vigorous growth of the plants. By the time of the accession of dry weather in August they had secured such a hold as to enable them to bear the drought of that month without much injury. From September 23 to October 8 measured plats of the different varieties were harvested in order to determine the comparative

yield per acre. Three square rods of each variety were gathered for this purpose. The weight of beets per acre was as follows:

	Tons.
Klein Wanzlebener Elite	20.56
Knauer	21.28
Lemaire	23.49
Desprez	26.42
Vilmorin	25.80
Klein Wanzlebener	24.60

In the north field the yield per acre was as follows:

	Tons.
Klein Wanzlebener Elite	18.10
Knauer	17.7
Lemaire	18.4
Desprez	21.2
Vilmorin	21.1
Klein Wanzlebener	22.5

The analyses of the samples of beets were commenced on the 15th of September, and consisted in examining a large number of beets individually and then in lots of ten, taking all the beets as they came. In this way a strict average comparison of the beets could be obtained. The varieties examined at different times show the influence of ripening or decay upon the content of sugar. The results of the various examinations are found in the following table:

Field A.

Variety.	Date.	Sucrose in juice.	Purity.
		Per cent.	
Klein Wanzlebener Elite	Sept. 12	12.6	75.9
	Oct. 13	14.5	84.6
	Oct. 31	14.2	83.9
Knauer	Sept. 12	11.5	75.7
	Oct. 14	14.8	88.0
	Nov. 2	13.2	82.1
Lemaire	Sept. 12	11.5	77.2
	Oct. 15	14.1	83.5
	Nov. 2	12.6	80.0
Desprez	Sept. 12	13.2	76.7
	Oct. 16	14.4	84.6
	Nov. 2	12.6	80.9
Vilmorin	Sept. 12	13.1	76.3
	Oct. 17	14.6	84.9
	Nov. 2	13.1	83.6
Klein Wanzlebener	Sept. 12	13.6	77.7
	Oct. 19	14.5	82.8
	Nov. 2	13.0	79.7

Field B.

Variety.	Date.	Sucrose in juice.	Purity.
		Per cent.	
Klein Wanzlebener Elite	Sept. 15	14.6	82.0
	Sept. 21	15.7	84.6
Knauer	Sept. 15	15.7	80.2
	Sept. 22	15.4	84.9
Lemaire	Sept. 15	13.2	77.0
	Sept. 26	13.8	81.2
	Oct. 20	14.6	88.5
Desprez	Sept. 15	13.8	81.3
	Oct. 6	13.5	....
	Oct. 21	14.1	87.7
Vilmorin	Sept. 15	14.3	....
	Oct. 8	13.8	....
	Oct. 22	13.4	85.8
Klein Wanzlebener	Sept. 15	14.7	....
	Oct. 10	14.7	....
	Oct. 23	14.1	83.8

The quantity of sugar produced per acre by the different varieties in the two fields is given in the following tables:

Field A.

Variety.	Weight per acre.	Sucrose in beets.	Sugar per acre.
	Tons.	*Per cent.*	*Pounds.*
Klein Wanzlebener Elite	18.1	13.8	5,001
Knauer	17.7	14.0	4,945
Lemaire	18.4	13.4	4,924
Desprez	21.3	13.7	5,837
Vilmorin	21.1	13.9	5,855
Klein Wanzlebener	22.5	13.8	6,204

Field B.

Klein Wanzlebener Elite	20.56	14.9	6,126
Knauer	21.28	14.9	6,341
Lemaire	23.49	13.8	6,473
Desprez	26.40	13.4	7,081
Vilmorin	25.80	13.9	6,838
Klein Wanzlebener	24.60	13.9	6,838

It was to be expected, from well-known facts connected with beet culture, that the growing of beets on practically virgin soil would tend to increase the tonnage per acre at the expense of the sugar content of the beets. It is gratifying, however, to see from the above results that the average content of sugar in the beets has been very little diminished by the increased tonnage. It should be remarked, however, that this increased tonnage is due to the fact that the beets were grown very closely together, and thus kept from becoming very large. In fact, the average weight of the beets grown upon the station is much less than it should be, but it was thought best to secure this result rather than to have overgrown beets with a low content of sugar.

It will be of interest to compare the results obtained at the station during its first year with the average results obtained in field culture in the beet-sugar countries of Europe. It will be understood, of course, that this is hardly a fair comparison, but it shows that with careful culture, even on the strong virgin soils of this country, the record of tonnage and saccharine strength compares very favorably with the general results obtained in field culture in Europe.

The full details of the work of the experiment station will be given in Bulletin No. 33, now in course of preparation.

YIELD OF BEETS PER TON—PERCENTAGE OF YIELD OF SUGAR IN BEETS IN EUROPE COMPARED WITH THE RESULTS OBTAINED AT SCHUYLER.

In respect of the tonnage of beets per acre and the average content of sugar in the beet for the different countries of Europe, it is difficult to give definite statements. The yield given in the official reports is the percentage of sugar obtained on the weight of the beet. We may safely assume, however, that between 80 and 85 per cent of the total weight of sugar in the beet is recovered in the process of manufacture. In regard to the tonnage per acre, the most reliable statements which we have access to give the following:

For the season of 1890–'91.

Austria-Hungary ... tons per acre ..	9.8
France ... do ...	11.3
Germany ... do ...	13.8

The yield on the experiment station of the Department at Schuyler, Nebr., during the past summer, average of all plats, was 21.7 tons per acre. In explanation of this, however, it should be said that the soil on which these beets were grown was practically a virgin soil, very fertile, and, therefore, the yield must be regarded as abnormally high. It is not infrequent, however, in Europe, to obtain 20 and even 25 tons per acre in exceptional circumstances, but this is not obtained in the beet fields taken as a whole. It is thought, however, that with the natural fertility of the soil of this country we may expect, when rational agriculture is introduced and with proper artificial fertilizers, to obtain an average yield of from 16 to 17 tons per acre.

In regard to the content of sugar in the beets, the following statements can be made:

The percentage of sugar obtained in Austria-Hungary during the season of 1890–'91 on the weight of beets secured was 11.02. Assuming that 80 per cent of the total weight of sugar in the beet was obtained, it would make the per cent of sugar in the beet 13.7.

The yield of sugar in France during the campaign of 1890–'91 on the weight of the beets worked was 11.61 per cent, which, on the same basis, would give the percentage of sugar in the beet 14.05.

The percentage of yield in Germany during the season of 1889–'90 was 12.35. Allowing as before 80 per cent of the sugar in the beets to be obtained, this would give the percentage of sugar in the beet 15.4. The yield of sugar for the campaign of 1890–'91 is stated to be practically the same.

The percentage of sugar in the beets grown by the Department at Schuyler was 13.8.

It is probable that a nearer value of the real content of sugar in the beets in Europe, calculated on the percentage of yield, would be obtained by using the factor 85 instead of 80. Calculated on this basis, the percentages would be as follows:

	Per cent.
Austria-Hungary	12.9
France	13.6
Germany	14.5

Collecting the above into tabular form, we have the following comparative statements:

	Tons per acre.	Sugar in beet on 80 per cent basis.	Sugar in beet on 85 per cent basis.
Austria-Hungary	9.8	13.7	12.9
France	11.3	14.5	13.6
Germany	13.8	15.4	14.5
Schuyler	21.7	Per cent sugar in beet 13.8.	

GROWTH OF SUGAR BEETS IN DIFFERENT PARTS OF THE COUNTRY.

In order to comply with a general demand for experimental work with sugar beets, 5½ tons of seed were purchased for general distribution. Two tons of this seed were purchased from Dippe Bros., of Quedlinburg, of the Klein Wanzlebener variety; two tons were purchased from Vilmorin, Andrieux et Cie, of Paris, of Vilmorin's Improved variety, and 1½ tons were purchased from the Oxnard Beet Sugar Company, of Grand Island, Nebr., of German and French sugar-beet seed,

These seeds were put up in packages averaging 13 ounces to a package, making in all 13,500 packages, and were sent to 4,600 persons. At the same time there was sent to each person receiving seed a copy of Farmers' Bulletin No. 3, giving instructions for the planting and cultivation of the beets. This bulletin is still available for distribution to those who write for it. Full directions were also sent for sampling the beets and sending them to the Department for analysis. The mean results obtained for each State are as follows:

Table showing mean composition of beets in each State, based on the average composition by counties.

State.	Samples.	Sucrose in beet.	Purity.	State.	Samples.	Sucrose in beet.	Purity.
	Number.	*Per cent.*	*Per cent.*		*Number.*	*Per cent.*	*Per cent.*
Arizona	2	7.69	56.9	Nebraska	59	11.44	75.1
Arkansas	2	6.39	58.9	Nevada	18	13.87	82.4
California	9	11.06	76.0	New Hampshire	1	11.62	80.0
Colorado	46	13.61	77.6	New Mexico	16	13.42	75.8
Connecticut	5	11.20	78.9	New York	4	11.05	74.3
Georgia	2	11.02	64.9	North Dakota	11	12.34	73.8
Idaho	1	12.73	74.9	Ohio	61	11.97	78.9
Illinois	36	11.15	75.0	Oklahoma Terr'y	1	6.37	53.0
Indiana	71	11.90	77.6	Oregon	33	13.95	84.5
Indian Territory	1	12.40	81.6	Pennsylvania	7	13.02	77.7
Iowa	314	11.39	75.3	South Dakota	202	12.20	74.4
Kansas	36	10.92	71.2	Tennessee	5	9.77	69.2
Kentucky	3	8.26	60.9	Texas	10	10.53	70.1
Maryland	2	7.75	68.5	Virginia	73	11.06	77.2
Michigan	46	12.77	77.9	Washington	11	14.75	84.2
Minnesota	34	11.56	74.7	Wisconsin	433	11.41	75.9
Missouri	11	10.93	73.5	Wyoming	15	13.04	78.0
Montana	40	13.14	72.5	New Jersey	1	7.33	70.8

NOTE.—It is necessary to give a number of precautions to the reader in order that he may not misapprehend the data given in the preceding table of analyses of beet samples.

In the first place it must be remembered that these beets were all sent by mail or express to the Department, and, with the exception of those localities which were near at hand, several days necessarily elapsed from the time of harvesting the beets until they were received for analysis. Careful experimental data show that beets which are harvested and exposed, even when wrapped for shipment by mail, lose water very rapidly, and therefore the quantity of sugar which the beet contains on analysis is greater really than it possesses in the normal state. It is probable, therefore, that the data given for the content of sugar will average at least 10 per cent too high. Again, it is not fair to compare States which furnished only a few samples, for instance, like Idaho, Arkansas, Arizona, Maryland, Kentucky, etc., with those States which furnished several hundred samples, like Iowa, South Dakota, and Wisconsin. The data must be taken simply to represent the character of the samples sent, and can not be reasonably construed to indicate the suitableness of the soil and climate of any particular State for the production of sugar beets. It must, however, be allowed that in those States, such as Oregon, Washington, and Montana, where the results are exceptionally high, the data show a peculiar suitability to the production of beets rich in sugar.

The State of Washington, with eleven samples, shows the best results of all, producing beets which had an average of 14.75 per cent of sugar, with a purity of 84.2. Next to Washington comes Oregon with 33 samples, showing 13.95 per cent of sugar and 84.5 purity. Other States showing excellent results are—

	Per cent.
Nevada	13.87
Colorado	13.61
New Mexico	13.42
Wyoming	13.04
Michigan	12.77
South Dakota	12.20
Indiana	11.90
Minnesota	11.56
Nebraska	11.44
Wisconsin	11.41
Iowa	11.39

One notable result is that in the arid regions where irrigation is practiced the beets produced are almost uniformly of a high character. The fine results obtained in Washington and Oregon are also most encouraging, inasmuch as in many States, especially on the Pacific coast, the winters are much milder than can be expected in Minnesota, Iowa, Nebraska, and the two Dakotas.

In a general way it is fair to say that with our present knowledge of the subject the culture of the sugar beet, for sugar-making purposes, is more likely to succeed in arid regions where irrigation is practiced and where the winters are mild, and on the Pacific coast, where the beets can be grown without irrigation and where the winters are also mild. This is not said in any way to discourage the introduction of the culture of the beet into other localities which show beets of fair quality but which are subject to winters of greater severity. As has already been indicated, the early advent of killing frost and freezing weather is a matter of serious consequence to beet-growers, interfering, as it does, with the proper harvesting and preservation of the beets.

Great difficulty is experienced in securing common methods of culture and harvesting the samples of beets. There are many cases in which the yield per acre of beet roots reported is absurdly high, reaching, in one case, 99 tons per acre. Any yield exceeding 25 tons per acre which is reported is looked upon with suspicion, and it is probable that the experimenter has made some mistake in determining the yield. While it is not impossible to grow 25 tons of sugar beets to the acre, yet it is very improbable that such a yield should be obtained if all the conditions necessary to the production of beets are observed.

In general, it may be said that the percentage of sugar which has been obtained in these general experiments is satisfactory. When it is remembered that in a great majority of cases many of the conditions necessary to success were doubtless neglected, and when it is further considered that the samples were subjected to every variety of cultivation and to almost every vicissitude of climate, the results can not but be regarded as satisfactory. It is evident, however, that investigations of this kind are not sufficient to secure the introduction of the beet-sugar industry.

The growth of a very small plat of beets is quite different from the cultivation of a large area, and it is yet very problematical whether the farmers of this country will be willing, as a class, to engage in beet culture as long as other forms of agriculture, less onerous and less expensive, prove remunerative. The culture of the sugar beet is essentially a practice of the highest class of agriculture, and will probably not be very popular until the farming lands of our country are more valuable. When farming lands get to be worth from $200 to $300 per acre, the yield of maize and wheat will probably not be sufficient to pay the rental on land of that price. In such case the farmers will be compelled to look for a crop which, under intensive culture, will bring a larger return. Such a crop is evidently to be found in the sugar beet.

In many cases capital has been found waiting to engage in the manufacture of beet sugar, but the promoters of the factory have found it impossible to secure the coöperation of farmers in sufficient numbers to insure a crop of reasonable magnitude. The purpose, therefore, of building a factory in such a locality was given up under compulsion.

Perhaps more serious difficulties in connection with the beet-sugar industry will be found in climatic conditions.

As has been pointed out before, in both annual and special reports of this Department, the area of our Northern States, especially the North Central States, suitable to the production of sugar beets is very large, and it has also been shown by the cultural experiments mentioned above that beets of fine saccharine strength and of large average tonnage per acre can be grown in these localities. The difficulties, however, of having the beets harvested and well secured before the acces-

sion of cold weather are very great. Especially during the present season, severe cold weather was experienced over many parts of the Northern Central States very early in November. It is reported that many thousands of tons of beets which had been grown for the use of factories in those localities were lost through this freezing temperature. It is quite certain that in all localities in our North Central States, and in all localities exposed to the frosts which are likely to occur from northwestern blizzards, arrangements will have to be made by the farmer to have his beet crop harvested and secured by the 1st of November. It is even to be feared that in some seasons the late October days may not be wholly secure against these sudden incursions of northern blizzards.

Whether or not the facilities afforded by these localities for the growth of beets will be considered a sufficient offset for the difficulties attending these climatic catastrophes, experience alone will show. To the region on the Pacific coast these remarks about climate do not apply. The winters of California, Oregon, and Washington are milder than those which prevail in the beet-growing regions of Europe, and it would be only fair to expect the most rapid increase in beet-sugar factories in those localities. Long experience has shown that beets will grow on the Pacific coast with fair tonnage and fair content of sugar, and the winters by their mildness afford exceptional opportunities for manufacture. It must not be supposed, however, that the severity of the winter must be considered an insuperable difficulty in the establishment of a beet-sugar industry. While the cost of siloing the beets may be a little greater, it will not be sufficiently great to wholly destroy the profit of the industry. Full details respecting the beets grown from the seed distributed by the Department will be found in Bulletin No. 33.

SYSTEMS OF TAXATION AND BOUNTY.

Many inquiries are received by the Department in regard to the fiscal system of European nations in respect of sugar beets. In order to supply the required information on this subject, the following digest of the laws of European countries manufacturing beet sugar is given. This digest contains the substance of the law now in force, or about to come into force, in those countries. Appended to this digest is the United States law relating to the bounty on sugar, concerning which numerous inquiries have been directed to this Department; also the law of Canada.

GERMANY.

The law which is at present in force in Germany in regard to the taxation of beet sugar, and the payment of bounties and rebates on exported sugar, went into effect on the 1st of August, 1888, and will expire by limitation of the Reichstag on the 1st of August, 1892.

By the terms of this law beets entering into manufacture are taxed 80 pfennigs ($0.1904)* per 100 kilograms (220.5 pounds)†. This is a reduction of 90 pfennigs from the old law. One of the great innovations of the new law was the imposition of a tax on all sugar entering into consumption in the German Empire of 12 marks ($2.856)‡ per 100

* The value of 1 pfennig is about a quarter of a cent, United States currency.
† The value of 1 kilogram is 2.2046 pounds avoirdupois.
‡ The value of 1 mark is 23.8 cents, United States currency.

kilograms. The rebates on exported sugar under the present law are as follows:

(1) For raw sugar polarizing at least 90 per cent, and for refined sugar containing less than 98 per cent, but at least 90 per cent of sugar, 8.50 marks.
(2) For candies and sugars in white hard loaves, etc., or crushed in the presence of revenue officers, and for all sugars of at least 99.5 purity, 10.65 marks.
(3) For all other hard sugar not containing over 1 per cent of water, and containing at least 98 per cent of sugar, 10 marks.

The amounts stated are for 100 kilograms.

It is thought that the present bounty or profit accruing to the manufacturers amounts to about 2.12 marks per 100 kilograms. The amount of tax collected in Germany for the campaign of 1889–'90 was as follows:

	Marks.	Dollars.
Tax on raw beets	78, 600, 315 =	18, 706, 874. 970
Amount paid in bounties	65, 900, 745 =	15, 684, 377. 310
Cost of collection, etc	3, 144, 011 =	748, 274. 618
Net receipts for the tax on beets	9, 555, 557 =	2, 274, 222. 566
Net receipts from tax on sugar entering into consumption	50, 814, 291 =	12, 093, 804. 258
Making total net receipts of the German treasury from the beet tax	60, 369, 848 =	14, 368, 023. 824

The following are the chief provisions of the new law in the German Empire, which was passed on the 31st of May, 1891, to go into effect on the 1st of August, 1892: (1) Tax on sugar entering into consumption, 18 marks per 100 kilograms; (2) the duty on imported sugar is fixed at 36 marks per 100 kilograms.

The rebates on exported sugar are paid on three classes of sugar, viz: A. Raw sugar polarizing at least 90° and under 98°; B. Candied, loaf, and other sugars polarizing at least 99.5°; C. Hard sugar containing not more than 1 per cent of water, crystals, lumps, etc., polarizing at least 98°.

The amount of drawback on each of these classes is fixed as follows:

From the 1st of August, 1892, to the 31st July, 1895:

A	1.25 marks per 100 kilograms.
B	2.00 marks per 100 kilograms.
C	1.65 marks per 100 kilograms.

From the 1st of August, 1895, to the 31st July, 1897:

A	1.00 marks per 100 kilograms.
B	1.75 marks per 100 kilograms.
C	1.40 marks per 100 kilograms.

The provisions of the rebate last for only five years, as will be seen, and this is called the transition period, after which it is supposed that no rebate in the form of a premium will be paid.

In case sugar which has been deposited in public warehouses has received the premium mentioned above, and is subseqently withdrawn for consumption at home, the premium which has been paid must be refunded to the treasury. A full description of the law is found in "Zeitschrift des Vereins für die Rübenzucker-Industrie," August, 1891, p. 571 *et seq.*

FRANCE.

In France a new law in regard to the taxing of sugar was promulgated in the Journal Officiel of the 30th of June. The law went into effect on the 1st of September, 1891. It reads as follows:

ARTICLE 1. Commencing from the 1st September next, and for the following campaigns, the legal yield per 100 kilograms of beets worked in the home sugar factories is fixed at 7.750 kilograms.

Where the actual yield of any factory does not exceed 10.5 kilograms of refined sugar per 100 kilograms of beets, the whole of the

excess is admitted to the benefit of the reduced duty enacted by the first paragraph of article 1 of the law of August 5, 1890. The half only of any excess obtained above 10.5 kilograms of sugar per 100 kilograms of beets is subject to this reduced duty, duty being levied on the other half at the full rate of 60 francs per 100 kilograms.

Those manufacturers who, previous to the 1st of November of each year, shall make declaration at the Bureau de la Régie, that they renounce any claim to the benefit of the premium on the excess over legal yield shall be allowed a drawback of 15 per 100 on the total amount of their manufacture. Sugars on which this drawback is allowed are subject to a duty equal to that applicable to the sugars representing the excess yields.

The *prise-en-charge* (legal yield) fixed by the first paragraph of the present article applies definitely under one or the other of the two modes of levying duty above defined, whatever may be the eventual excess of deficit.

ART. 2. The drawback on manufacture allowed to manufacturers who are also distillers by article 6 of the law of August 5, 1890, is reduced to 15 per cent, commencing from the campaign of 1891–'92.

ART. 3. Molasses delivered from one factory to another or to a *sucraterie* under fiscal supervision is credited to the manufacturing account at the rate of 30 kilograms of refined sugar per 100 kilograms of molasses. It is taken into account at the factory where delivered for the quantity of refined sugar with which the account of the sender has been credited. Only molasses already worked and containing not more than 50 per cent 100 of absolute sugar is subject to these conditions.

ART. 4. No modification with regard to the fixing of the legal yield or the drawback, which may be the object of further legislation, shall be applicable before the expiration of one year from the promulgation of the new law.

Temporary provision.

ART. 5. For the campaign of 1890–'91 a drawback of 15 per 100 on the total quantity manufactured shall be allowed to those sugar manufacturers who, by declaration made at the Bureau de la Régie within five days at the latest from the promulgation of the present law, shall renounce any claim to the benefit of the premium on sugar obtained above the legal yield.

The last paragraph but one of article 1, cited above, is applicable to the sugars representing this drawback.

The tax on imported sugar in France is 60 francs* per 100 kilograms. As will be seen, the manufacturer pays at the rate of 30 francs for all sugar in excess of the legal yield of 7.75 kilograms up to 10.5 kilograms. On all sugar over this he pays the full tax of 60 francs per 100 kilograms on one-half of the excess above 10.5 and 30 francs per 100 kilograms on the other half.

The following computation may be made of premiums received by the French manufacturers of sugar when they export it under the present law:

If the beets yield 11 per cent of sugar, the premium amounts to 8.85 francs per 100 kilograms. If the yield be ten per cent, the premium amounts to 8.25 francs per 100 kilograms. If the yield be 9 per cent, the premium will amount to 5.70 francs per 100 kilograms. It is also seen that by one of the conditions of the law all manufacturers are guarantied certain premiums if they renounce any claim to the excess over the legal yield. They will then receive a fixed premium of 4.50 francs per 100 kilograms, being 15 per cent of 30 francs duty which is to be paid. It should also be stated that there is an extra tax of 7 francs per 100 kilograms on all beet sugar imported into France. This tax is not collected on cane sugar imported. In short, according to

*The value of 1 franc is 19 cents, United States currency.

the new law, it appears that the French Government will guaranty to manufacturers of sugar a minimum premium of 4.50 francs per 100 kilograms of sugar. For those manufacturers who work with rich beets, the premium will vary from 8 to 9 francs per 100 kilograms, according to the richness of the beets.

AUSTRIA-HUNGARY.

In Austria the duties on imported sugar, payable in gold, are as follows: On white sugar, 50 francs per 100 kilograms; on raw sugar below 19, Dutch standard, 37.50 francs per 100 kilograms; on sirups, glucose, and molasses, 15 francs per 100 kilograms; there is a duty on indigenous sugar entering consumption of 23.65 francs per 100 kilograms.

When sugar is exported, the following direct premiums are paid:

	Francs.
Per 100 kilograms of sugar polarizing from 88 to 93	3.22
Per 100 kilograms of sugar polarizing from 93 to 99.5	3.44
Per 100 kilograms of sugar polarizing from 99.5 to 100	4.94

The annual maximum of premiums is not to exceed 5,000,000 florins,* or 10,750,000 francs. If the premiums on exported sugar exceed this sum, the excess is to be reimbursed by the sugar factories in proportion to their production. A bond is given by the factories to secure this reimbursement. This bond is 11,000 florins or 23,650 francs ($4,564.450) for each sugar factory.

RUSSIA.

In Russia the new sugar law which has just gone into effect contains the following provisions. The duty on imported sugar is as follows:

For refined sugar	97.68 francs per 100 kilograms.
For brown sugar	73.26 francs per 100 kilograms.

The minister of finance has authority to lower this duty to 36.63 francs per 100 kilograms if the price of sugar reaches 6 ($3.528) to 6.5 ($3.822) rubles† per pood‡ (36.068 pounds) at St. Petersburg, or 5 to 5.5 rubles per pood at Kieff.

The excise duty for sugar in consumption amounts to 17.27 francs per 100 kilograms. Beginning with the campaign of 1892–'93, a supplementary duty will be imposed on refined sugar of 40 kopecks§ ($0.235) per pood, equivalent to 6.83 francs per 100 kilograms; so the total tax for sugar entering consumption from that time will be 24.10 francs per 100 kilograms of refined sugar. The excess of the import tax over the tax on consumption will then be as follows:

For raw sugar	73.26—17.27=55.99 francs per 100 kilograms.
For refined sugar	97.63—24.10=73.58 francs per 100 kilograms.

Admitting that the Government will reduce the duty on imported sugar to the minimum of 1.50 rubles in gold per pood, there will still remain for the manufacturer of sugar in Russia an assured premium, on exportation, of 19.36 francs per 100 kilograms for raw sugar, and 12.53 francs per 100 kilograms for refined sugar. At the present

*The value of the Austrian florin in francs as given above is 2.15. The ratio in gold coin as fixed by the United States Treasury is 1.88 francs.

†The value of 1 ruble is about 77 cents, United States currency.

‡The value of 1 pood is 36 English pounds avoirdupois.

§The value of 1 kopeck is about 0.60 cents, United States currency.

import duty, however, the premiums are greater than that mentioned above.

HOLLAND AND BELGIUM.

In Holland as well as in Belgium the tax upon raw sugar is fixed upon the volume and density of the juice. The legal yield is fixed at 1.46 kilograms of refined sugar or 1.65 kilograms of brown sugar per hectoliter of juice for each degree of density. The tax amounts to 27 florins, equivalent to 56.43 francs, per 100 kilograms of refined sugar. The duty on imported sugar in Holland is as follows:

Candied sugar of the first class, 31.86 florins, equivalent to 66.59 francs, per 100 kilograms.

Candied sugar of the second class, 28.89 florins, equal to 60.38 francs, per 100 kilograms.

White sugar polarizing above 99°, 27 florins, equal to 56.43 francs, per 100 kilograms.

Raw sugars, for each degree of polarization, .27 florins, equal to .56 francs, per 100 kilograms.

The minimum amount of money which the treasury is to receive from sugar is fixed by law for the campaigns of 1892–'93 and 1893–'94 at 8,500,000 florins ($3,417,000). Any deficit in this amount is to be made up by the sugar manufacturers.

SWEDEN.

The duty on indigenous sugar entering consumption is one-half of the duty on imported sugar from May 22, 1891, for sugars below No. 19, Dutch standard. The duty is collected on the weight of beets entering the factory, assuming that the yield in raw sugar is 6.25 per cent on the weight of beets worked.

The rate of duty on imported sugar below No. 18 is 23.5 kronen, equal to 33 francs, per 100 kilograms.

The tax on home-grown raw sugar is therefore 11.75 kronen, equal to 16.5 francs, per 100 kilograms.

DENMARK.

The duty on imported sugar is fixed at the following rates from October, 1891: White sugar above No. 18, Dutch standard, 6 oere* per livre;* white sugar above 9, Dutch standard, 3 oere per livre; white sugar darker than above, 2 oere per livre; molasses and sirup, 1 oere per livre; indigenous sugar is taxed for consumption at the rate of 2.25 oere per livre for sugar above No. 19.

If, however, the total quantity of sugar made does not exceed 32,000,000 kilograms (70,547,200 pounds), then the manufacturers are not required to make good the deficit. The amount of deficiency which each manufacturer is compelled to pay shall in no case ever exceed 6 florins per 100 kilograms of the excess of sugar over the minimum fixed above.

The amount which each manufacturer is compelled to pay is fixed by the minister of finance, and is to be paid within a month after its publication in the *Journal Officiel*.

ITALY.

From November 21, 1891, the duties on sugars imported into Italy are as follows: Sugar of first class, per 100 kilograms, 92 francs; sugar of second class, per 100 kilograms, 76.75 francs. Sugars of first class include all above 20, Dutch standard, or polarizing above 98 degrees.

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* 1 livre = 200 grams; 100 oere = 1.40 francs.

The excise tax on sugar of domestic production is as follows: For sugars of first class, per 100 kilograms, 63.15 francs; for sugars of second class, per 100 kilograms, 55.95 francs.

Indigenous sugar is fostered, therefore, by a protective duty equal to the difference between the tariff on imported sugars and the excise tax on indigenous sugars. This amounts in sugars of the first class to 28.85 francs per 100 kilograms, and in sugars of the second class to 20.80 francs per 100 kilograms.

CANADA.

The governor in council may authorize the payment, out of the consolidated revenue fund of Canada, under such regulations and restrictions as are made by order in council, to the producers of any raw beet sugar produced in Canada wholly from beets grown therein, between the 1st day of July, 1891, and the 1st day of July, 1893, of a bounty of $1 per 100 pounds, and, in addition thereto, 3½ cents per 100 pounds for each degree or fraction of a degree over 70 degrees shown by the polariscopic test.

UNITED STATES LAWS IN REGARD TO SUGAR.

[Act of October 1, 1890, 26 Stat., 567.]

Bounty on sugar.

On and after July first, eighteen hundred and ninety-one, and until July first, nineteen hundred and five, there shall be paid from any moneys in the Treasury not otherwise appropriated, under the provisions of section three thousand six hundred and eighty-nine of the Revised Statutes, to the producer of sugar testing not less than ninety degrees by the polariscope, from beets, sorghum, or sugar cane grown within the United States, or from maple sap produced within the United States, a bounty of two cents per pound; and upon such sugar testing less than ninety degrees by the polariscope, and not less than eighty degrees, a bounty of one and three-fourths cents per pound, under such rules and regulations as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, shall prescribe.

Notices, applications for license, and bonds.

The producer of said sugar to be entitled to said bounty shall have first filed prior to July first of each year with the Commissioner of Internal Revenue a notice of the place of production, with a general description of the machinery and methods to be employed by him, with an estimate of the amount of sugar proposed to be produced in the current or next ensuing year, including the number of maple trees to be tapped, and an application for a license to so produce, to be accompanied by a bond in a penalty, and with sureties to be approved by the Commissioner of Internal Revenue, conditioned that he will faithfully observe all rules and regulations that shall be prescribed for such manufacture and production of sugar.

Licenses.

The Commissioner of Internal Revenue, upon receiving the application and bond hereinbefore provided for, shall issue to the applicant a license to produce sugar from sorghum, beets, or sugar cane grown within the United States, or from maple sap produced within the United States, at the place and with the machinery and by the methods described in the application; but said license shall not extend beyond one year from the date thereof.

No bounty shall be paid to any person engaged in refining sugars which have been imported into the United States, or produced in the United States upon which the bounty herein provided for has already been paid or applied for, nor to any person unless he shall have first been licensed as herein provided, and only upon sugar produced by such person from sorghum, beets, or sugar cane grown within the United States, or from maple sap produced within the United States. The Com-

missioner of Internal Revenue, with the approval of the Secretary of the Treasury, shall from time to time make all needful rules and regulations for the manufacture of sugar from sorghum, beets, or sugar cane grown within the United States, or from maple sap produced within the United States, and shall, under the direction of the Secretary of the Treasury, exercise supervision and inspection of the manufacture thereof.

Payment of bounties—No bounty upon less than five hundred pounds.

And for the payment of these bounties the Secretary of the Treasury is authorized to draw warrants on the Treasurer of the United States for such sums as shall be necessary, which sums shall be certified to him by the Commissioner of Internal Revenue, by whom the bounties shall be disbursed, and no bounty shall be allowed or paid to any person licensed as aforesaid in any one year upon any quantity of sugar less than five hundred pounds.

Penalties.

That any person who shall knowingly refine or aid in the refining of sugar imported into the United States, or upon which the bounty herein provided for has already been paid or applied for, at the place described in the license issued by the Commissioner of Internal Revenue, and any person not entitled to the bounty herein provided for, who shall apply for or receive the same, shall be guilty of a misdemeanor, and upon conviction thereof shall pay a fine not exceeding five thousand dollars, or be imprisoned for a period not exceeding five years, or both, in the discretion of the court.

Import duties—Beet-sugar machinery free until July 1, 1892.

All sugars above number sixteen Dutch standard in color shall pay a duty of five-tenths of one cent per pound: *Provided,* That all such sugars above number sixteen Dutch standard in color shall pay one-tenth of one cent per pound in addition to the rate herein provided for, when exported from, or the product of, any country when and so long as such country pays or shall hereafter pay, directly or indirectly, a bounty on the exportation of any sugar that may be included in this grade which is greater than is paid on raw sugars of a lower saccharine strength; and the Secretary of the Treasury shall prescribe suitable rules and regulations to carry this provision into effect: *And provided further,* That all machinery purchased abroad and erected in a beet-sugar factory and used in the production of raw sugar in the United States from beets produced therein shall be admitted duty free until the first day of July, eighteen hundred and ninety-two: *Provided,* That any duty collected on any of the above-described machinery purchased abroad and imported into the United States for the uses above indicated since January first, eighteen hundred and ninety, shall be refunded.

Sugar candy and all confectionery, including chocolate confectionery, made wholly or in part of sugar, valued at twelve cents or less per pound, and on sugars after being refined, when tinctured, colored, or in any way adulterated, five cents per pound.

All other confectionery, including chocolate confectionery, not especially provided for in this act, fifty per centum ad valorem.

Glucose, or grape sugar, three-fourths of one cent per pound.

Provisions take effect April 1, 1891.

That the provisions of this act providing terms for the admission of imported sugars and molasses, and for the payment of a bounty on sugars of domestic production, shall take effect on the first day of April, eighteen hundred and ninety-one: *Provided,* That on and after the first day of March, eighteen hundred and ninety-one, and prior to the first day of April, eighteen hundred and ninety-one, sugars not exceeding the number sixteen Dutch standard in color may be refined in bond without payment of duty, and such refined sugars may be transported in bond and stored in bonded warehouse at such points of destination as are provided in existing laws relating to the immediate transportation of dutiable goods in bond, under such rules and regulations as shall be prescribed by the Secretary of the Treasury.

Free list.

Sugars, all not above number sixteen Dutch standard color, all tank bottoms, all sugar drainings and sugar sweepings, sirups of cane juice, melada, concentrated melada, and concrete and concentrated molasses, and molasses.

Conditional duty on sugar.

That with a view to secure reciprocal trade with countries producing the following articles, and for this purpose, on and after the first day of January, eighteen hundred and ninety-two, whenever, and so often as the President shall be satisfied that the Government of any country producing and exporting sugars, molasses, coffee, tea, and hides, raw and uncured, or any of such articles, imposes duties or other exactions upon the agricultural or other products of the United States, which in view of the free introduction of such sugar, molasses, coffee, tea, and hides into the United States he may deem to be reciprocally unequal and unreasonable, he shall have the power, and it shall be his duty, to suspend, by proclamation to that effect, the provisions of this act relating to the free introduction of such sugar, molasses, coffee, tea, and hides, the production of such country, for such time as he shall deem just, and in such case and during such suspension, duties shall be levied, collected, and paid upon sugar, molasses, coffee, tea, and hides, the product of, or exported from, such designated country, as follows, namely:

All sugars not above number thirteen Dutch standard in color shall pay duty on their polariscopic tests as follows, namely:

All sugars not above number thirteen Dutch standard in color, all tank bottoms, sirups of cane juice or of beet juice, melada, concentrated melada, concrete and concentrated molasses, testing by the polariscope not above seventy-five degrees, seven-tenths of one cent per pound; and for every additional degree or fraction of a degree shown by the polariscopic test, two-hundredths of one cent per pound additional.

All sugars above number thirteen Dutch standard in color shall be classified by the Dutch standard of color and pay duty as follows, namely: All sugar above number thirteen and not above number sixteen Dutch standard of color, one and three-eighths cents per pound.

All sugar above number sixteen and not above number twenty Dutch standard of color, one and five-eighths cents per pound.

All sugars above number twenty Dutch standard of color, two cents per pound.

Molasses testing above fifty-six degrees, four cents per gallon.

Sugar drainings and sugar sweepings shall be subject to duty either as molasses or sugar, as the case may be, according to polariscopic test.

Alcohol free of tax for making sugar from sorghum.

[Extract from act approved March 3, 1891, making appropriations for the Department of Agriculture for the fiscal year ending June 30, 1892.]

That any manufacturer of sugar from sorghum may remove from distillery warehouses to factories, used solely for the manufacture of such sugar from sorghum, distilled spirits in bond free of tax, to be used solely in such manufacture of sugar from sorghum; that all distilled spirits removed as herein authorized shall be of an alcoholic strength of not less than one hundred and sixty per centum proof, and may be removed, stored, and used in the manufacture of sugar from sorghum, and when so used may be recovered by redistillation in the sugar factory of such sugar manufacturer under such bonds, rules, and regulations for the protection of the revenue and the accomplishment of the purposes herein expressed as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may prescribe.

Any person who removes or uses distilled spirits in violation of this provision, or the regulations issued pursuant thereof, shall, on conviction thereof, be fined not less than one thousand dollars nor more than five thousand dollars for each offense, and the spirits and the premises on which such spirits are used shall be forfeited to the United States.

THE MUCK LANDS OF THE FLORIDA PENINSULA.

The establishment by this Department of an experimental station at Runnymede, Fla., for investigating the growth of sugar cane in reclaimed swamp muck has rendered some account of that kind of soil important.

The possibilities of bringing into successful cultivation the swamp lands of Florida have occupied the minds of capitalists for several years. It has now been about ten years since Mr. Hamilton Disston, of Philadelphia, formed the plan of reclaiming the swamp lands of Florida for agricultural purposes by drainage canals. These lands are found in detached localities over the whole State, but the parts of them which demand our attention at the present time are found extending from near the central portion of the peninsula in a southerly direction to Lake Okeechobee, and thence into the Everglades to the Gulf. It is

on these lands that the experiments of reclamation have been made, and several thousand acres of swamp lands have been already freed of water and made ready for cultivation. Of these lands, at the present time, about 2,000 acres are planted in sugar cane, from 5,000 to 6,000 acres in rice, and quite a large area in gardens.

Vast tracts of reclaimed land, however, are still in the wild state, the water simply having been taken off them, but no attempts having been made to fit them for cultivation.

The muck lands, which form the subject of the present paper, begin near the head waters of the St. Johns, about 20 miles southeast of the town of Orlando. These lands form the borders of the lakes and rivers, but the chief deposits are about the lakes. The configuration of the internal lakes of Florida is of the simplest nature. About the edges of the lakes the waves have thrown up a ridge of sand and muck, and this ridge is usually covered with cypress trees. Back of these come the swamp lands proper, which, during the greater part of the year, before the system of drainage was established, were under water. These swamp lands vary in width from a very few feet to many miles, and are bordered in turn by the sand and pine lands.

The first of these lakes in geographical order is known as Lake Hart. A canal has been cut from this lake to the head waters of the St. Johns, and a large area of rich vegetable mold has been recovered. All other systems of drainage in the lands to which reference is made are drained toward the south, Lake Hart marking the watershed between the head waters of the St. Johns and the head waters of the Kissimmee. Only a few miles south of Lake Hart is found Lake East Tohopekaliga. This lake has been drained by a canal into Lake Tohopekaliga, on the shores of which is found the town of Kissimmee. Lake Tohopekaliga has also been connected by a drainage canal with Lake Cypress, and Lake Cypress by another drainage canal with Lake Kissimmee. Lying east of Lake East Tohopekaliga is found another series of lakes, viz, Lake Preston, the most northern one, Lake Alligator, central, and Lake Gentry, the most southern of the three. These lakes are soon to be connected by drainage canals, and the last one, Lake Gentry, is to be opened into Lake Cypress. About sixty sections of land, or, in all, about 40,000 acres of rich muck land will be recovered as soon as these canals are finished.

Passing from Lake Kissimmee into the Kissimmee River, we find a stream bordered on both sides by rich deposits of muck passing gradually into the sand and pine lands back of them. The river is extremely tortuous, and while the distance from Lake Kissimmee to Lake Okeechobee is only about 60 miles in a direct line, a boat, following the course of the river, passes over nearly 150 miles in order to reach the lake.

No attempts have been made so far to reclaim the muck lands bordering the Kissimmee River by canals, and it is not possible to accomplish this by natural drainage. The level of the Kissimmee River, even at low water, is almost the same as that of the muck lands bordering it, and, during the rainy season, lasting from June till October, the river becomes a veritable lake. There would, therefore, be no possibility of natural drainage for these lands, but by the construction of levees along the river and the introduction of pumps, many thousands of acres could be recovered. Artificial drainage is no longer an experiment, but in many parts of the country it is practiced with entire success. The plantations on the Mississippi River below New Orleans are nearly all provided with artificial drainage systems, inasmuch as the natural drainage in that locality is entirely insufficient to free the lands

from water. The great fertility of the Florida muck soils would render such a system of drainage profitable as soon as the country is opened up to the markets of the North.

Passing from the Kissimmee River through Lake Okeechobee, we come to the largest body of muck lands in the world. The northern shores of Lake Okeechobee are fringed with a very little muck, but as you approach the southern border the muck deposits become deep and wide until finally they merge into those vast deposits of muck which form the northern border of the Everglades. The exact extent southward of this body of muck is not known, but it has been accurately surveyed for a distance of about 50 miles, and found to be of excellent character throughout the whole of this distance.

As has been said before, the problem of drainage for the muck lands for the central portion of the peninsula, beginning with Lake Hart and continuing to Lake Cypress, is an exceedingly simple one. All that is necessary to secure the drainage is the construction of canals. This is easily done by dredge boats, inasmuch as the muck is easily moved and a good dredge boat is able to cut 300 feet of muck a day, 8 feet deep and 50 feet wide. When, however, we come to the vast deposits of muck on the Okeechobee, the problem is quite a different one. Two methods of procedure have been proposed. One of these contemplates nothing else than the drainage of Lake Okeechobee itself. This body of water is a peculiar one. It receives through its principal tributaries and the Kissimmee River most of the drainage of the central peninsula of Florida. It has, however, no outlet except the overflow through the Everglades into the Gulf and westerly through the marshes into the head waters of the Caloosahatchee. The building of a canal to the Atlantic Ocean, which would remove the surplus water of the Okeechobee and permanently lower its level, would be an undertaking of considerable magnitude. The nearest distance is about 40 miles directly eastward from the central eastern part of the lake. The whole of this distance, however, would be through sand which, of course, is much more difficult to move, on account of its greater compactness and greater weight than the muck itself; it is therefore probable that it would be more economical to cut the canal in a southerly direction from the center of the southern border of the lake directly through the muck into the Everglades. A careful computation of the amount of drainage received by Lake Okeechobee would show that for the purpose of securing open drainage during the rainy season, the canal would have to be 300 feet wide and 12 feet deep. Such a canal would permanently lower the water 6 feet in the lake and would make ready for cultivation the vast body of muck lands already described.

The second method proposed is one which is now actually in operation, viz, the drainage of a portion of the muck lands of the Okeechobee. The system which is proposed, and which is now largely completed, looks to the recovery of only a portion of the land on the southwestern border of the lake. Lake Hicpochee is a small body of water, which, at its nearest point, is distant only about 6 miles from Lake Okeechobee. A canal has been constructed from Lake Okeechobee to Lake Hicpochee. A longer canal, about 18 miles, has also been built almost directly east from Lake Hicpochee to connect with Lake Okeechobee at another point. Westerly from Lake Hicpochee a canal has already been built into Lake Bonne and Lake Flirt connecting them with the head waters of the Caloosahatchee.

The next step in this scheme for the reclamation of this body of land consists in the erection of a levee along the borders of the lake. This

levee is to extend to the pine lands at two points, one about 15 miles north of Lake Hicpochee and another at some point south of it, at such convenient distance as may be found necessary for the work. The levee along the bank of the Okeechobee will completely protect this portion of the land from any overflow from this lake. The drainage through the system of canals established to the head waters of the Caloosahatchee will be sufficient to carry off the natural rainfall of this body of land. About 50,000 acres of land are included already in the canals which are under construction, and a very little additional expense would increase this area to 100,000.

Col. J. M. Kreamer, at my request, has made an approximate estimate of the total amount of muck lands indicated in the scheme already given. He estimates the amount at 1,000,000 acres. He says:

> These lands are found in bodies of greater or less extent throughout the Kissimmee valley, the northern limit being in the vicinity of Lake Hart. A map of the region west of Lake Okeechobee shows, in detail, the extent and depth of saw grass or muck soil, and the ease with which it can be reclaimed and cultivated by labor-saving appliances was fully discussed by us during your recent trip through the Okeechobee country. This tract is now (July 22, 1891,) virtually dry, due to the low stage of water in Okeechobee and vicinity. The surface of the soil is at least 30 inches above the water level. Reports from Okeechobee show that the muck lands south of the lake are all at present above the water level from 18 inches to 2 feet. We are cutting a canal to the southwest from a point on the shore of Lake Okeechobee near Ritta River.

By the single canal connecting Lake Okeechobee with Lake Hicpochee and thence to the Caloosahatchee, the level of the water in the Okeechobee has been permanently lowered from a foot to 18 inches. If one small canal, through the imperfect drainage system of the Caloosahatchee River, can secure this result, we can easily imagine the success which would attend the construction of the large canal mentioned above.

The total elevation of the highest point of this muck land system, viz, Lake Hart, above the tide level is about 72 feet. Lake Okeechobee itself is 20 feet above the tide. It is thus seen that there is abundant natural fall to carry off the whole of the water provided a canal of sufficient size can be constructed.

The origin of the muck soil is, of course, vegetable matter. There are no data for estimating the length of time required for the formation of these muck deposits. It is known that it must have been of great duration. For this reason it is not probable that the flora which is found over the muck region at the present time would represent accurately the character of the vegetation in prehistoric times. I have had samples collected of the principal vegetable growths which cover the muck lands at the present time. The whole of the Okeechobee muck lands is covered almost exclusively by saw-grass. This is a cyperaceous plant of the genus *Cladium;* its botanical name is *Cladium Mariscus* or *C. effusum.* During the winter and early spring months this dense growth of grass often becomes dry enough to burn, and large areas are often burned over. Other plants which are, at present, contributing to the growth of muck, are as follows:

Common name.	Botanical name.
Yellow pond lily	Nymphea flava.
Maiden cane grass	Panicum Curtisii.
Alligator wampee	Pontederia cordata var.
Sedge	Cyperus sp.
Fern brake	Osmunda sp.
Mallow	Malva sp.
Broom sedge	Andropogon sp.
Arrow weed	Sagittaria.

In regard to the depth of the soil, it varies from the merest covering at the edges near the sand to from 15 to 16 feet in its deepest portions. The greater part of the muck lands, as before indicated, will vary from 3 to 6 feet in depth, while along the Okeechobee the average depth is much greater. The soil varies in color from almost jet black to black brown.

The subsoil lying under the muck in the upper region around Kissimmee is pure sand. The Okeechobee muck, however, is underlaid with a thick stratum of shell marl containing pebbles very rich in phosphorus, and this rests upon a coralline or limestone formation. This limestone formation is very porous in structure, full of cavities of varying sizes, capable of being ground with extreme ease and thus prepared for application to the soil. At distances which vary from 2 or 3 miles to perhaps 15 or 20 from the shore of the lake this limestone formation comes nearest to the surface and forms a kind of a natural dam for the waters of the lake. This line of demarcation may properly be considered as the border between the Lower and Upper Everglades.

Of course every plan of constructing a canal through the muck lands must include the breaking up of this crust when it approaches the surface. This, however, is most easily done and would oppose no great barrier to the progress of the work. This crust has already been broken through by the drainage company in opening the Upper Caloosahatchee to a freer connection with Lake Okeechobee, through Lakes Flirt and Boone, by the system of canals already described.

As will be seen further on, the muck soils of Florida are markedly deficient in mineral constituents. The presence, therefore, of so large a body of limestone, mingled with phosphatic pebbles, is a matter of no mean importance when the agricultural future of these lands is considered. A few of these pebbles were picked up at the headwaters of the Caloosahatchee and examined for phosphoric acid. The mean percentage of phosphoric acid found was 0.697. This region has not been prospected at all for phosphate deposits, but it would not be surprising if they were discovered to exist here in great abundance, as they are found from 60 to 100 miles farther west, in the Peace River region.

The question of the subsidence of these soils under cultivation is also one of considerable importance. If the organic matter which they contain should decay there would, of course, be a marked depression in the level of the soil. The oldest portions of the muck land in cultivation have now been tilled for about eight years. In these lands, where sugar cane was planted it has been found that there has been a subsidence of several inches, so that the stubble of the sugar cane has been left protruding to this distance above the surface. This depression, however, seems to have occurred chiefly in the first two or three years of the cultivation, and there seems to have been no such marked lowering in the surface of the soil since that time. It is not likely, therefore, that the soil will ever again be sufficiently depressed to bring it under the level of the water, although it must be confessed that the period of observation has been entirely too short to make any definite prophecy in regard to the future.

The organic matter, however, of the muck lands does not seem to be subject to complete decomposition by the natural processes of decay. The humic bodies, consisting largely of carbon, appear to be capable of resisting partially, if not altogether, the oxidation to which they are exposed by cultivation. There is considerable danger, however, from fire, especially during the dry season. When fires are once started with dry muck they continue to burn until the lands are flooded on the

accession of the rainy season. But even in cases where a complete burning of the soils by conflagrations of this kind is observed the depression does not appear to be very great, and these places are entirely above the water line, except, perhaps, in times of very severe rains. There is, therefore, it is thought, no danger in the future of such a depression of the land as to render unavailing the drainage which has been accomplished.

The question of climate is also one of prime importance, especially in consideration of the culture of sugar and rice.

In regard to precipitation, the climate of Florida is divided distinctly into a rainy and a dry season. The rainy season begins early in the summer, in the latter part of May or June, and continues until about the middle of September or the 1st of October. From October to June the climate of the central peninsula of Florida is essentially dry, although showers may frequently occur. This distribution of the rainfall has its advantages and disadvantages. So far as the culture of rice is concerned, it is extremely advantageous. The rainy season occurs during the time when the rice fields are to be flooded, and thus the necessity for artificial flooding is greatly diminished by the great rainfall of the summer. There is also an advantage to the growing cane crop in having the rainfall come during the hot months, at the period of most rapid growth. It is equally as advantageous, however, during the manufacturing period, to have a dry season. For this reason the period of the manufacture of sugar in Florida has many advantages over the same time of the year in Louisiana. In Louisiana, especially after November, the planter is exposed to frequent and protracted rains, rendering the fields muddy, and the roads over which the cane is to be hauled almost impassable. The Florida planter can confidently count on a continuous manufacturing season, being rarely interrupted by rains. The disadvantages of the dry season in the central peninsula of Florida are chiefly felt by the growers of vegetables. These vegetables are grown for the early northern markets, and the gardening period in central Florida begins about the last of December, and ends about the first of May. It is during this season that rains are most infrequent, and therefore the gardener is subjected to grave dangers from drought. It is during the same period, too, that the spring planting of sugar cane takes place, and, owing to the dry weather, the planted cane may be affected with dry rot. The disadvantages, however, of the dry season are easily overcome by artificial irrigation, which, on account of the level surface of the soil and the short distance which the water must be pumped, is rendered particularly easy. By establishing a pump near a branch of the lake and raising the water about 8 feet, the whole of the muck lands can be easily irrigated. It is not necessary that the water be brought to the surface of the soil at all, as, on account of the porous nature of the muck, the land is thoroughly moistened by subirrigation; it is only necessary to bring the water high enough to allow it to flow into the drainage ditch to secure a complete permeation of the soil with moisture. Upon the whole, therefore, in regard to precipitation, it may be said that the climate of the central peninsula of Florida is favorable, not only to the growth of the staples—sugar and rice—but also for market gardening.

In regard to the temperature, equally favorable conditions obtain. Frosts are of rare occurrence, and when they do occur usually do but little injury. Only twice in eight years have the eyes of the cane been injured by frost, and even in these cases they were not all killed. In no instance has cane been known to freeze in the Florida peninsula,

during the period over which these observations extend. It may be said, therefore, that no danger need be apprehended by the planter, even in the central portion of the peninsula, from frost. On account of this immunity from frost, the cane may be allowed to ripen during the months of November and December, and grinding operations need not begin until January or even later. The climatic conditions of temperature, therefore, in this respect, approach those of the island of Cuba. This being true of the central portion of the peninsula, it is true in a much greater degree of the lower portion, viz, the Okeechobee section. In this region frosts are almost entirely unknown. The cocoanut and the date palm flourish, and tropical plants of every description predominate over the subtropical. In March, 1891, during a visit to this region, numerous fields of cane were seen along the Caloosahatchee which had not yet been cut, and which, although not entirely green, were only affected in color by the maturity of the plant presenting a rich yellowish green. In this region the sugar cane is absolutely free from any danger from frost, although occasionally light frosts have been known to injure more delicate plants. It may be said, then, with confidence that in the region of the Okeechobee Lake the lands which may be recovered for sugar-making purposes have all the advantages of the climate of Cuba.

The manufacture of sugar from the cane in this region may be postponed with perfect safety until the beginning of February, and the months of February, March, and April be the months of greatest activity in sugar manufacture.

On account of the ease of irrigation, the whole area of the muck lands of Florida is particularly well suited to the growth of rice. In regard to the actual success of rice culture, however, it is not possible to speak from any but theoretical considerations, inasmuch as until the present year no experiments of any consequence have been made in rice culture. During the present season several thousand acres have been planted in rice on the muck and semimuck lands of the State, and the result of this trial will be awaited with interest by those interested in the agriculture of that region.

In regard to the culture of rice, it may be said that it can be grown on the muck lands of slight depth, known as prairie lands. These lands often have a covering of only a few inches of muck, underneath of which is found firm, hard, white sand. These lands are not suitable to the culture of cane, but are supposed to be well suited to the growth of rice.

Another important consideration in connection with the muck lands of the Okeechobee country is found in the method contemplated for their cultivation. These lands will be intersected by numerous drainage canals, and by means of these canals not only can the land be cultivated by steam from engines carried on boats in the canals themselves, but also the products of the fields can be transported on the same canal, with an economy which will render the competition of mule or horse power methods of cultivation almost impossible. Competent engineers have made estimates for the actual cost of steam cultivation, on the canal system indicated above, and, allowing for all contingencies of unexpected expenses, it appears reasonable to say that, with the yield of cane which can be secured on such lands, it will be possible to place the cane at the doors of the factories, by means of a system of canals used in irrigation and cultivation, at an expense which will fall below $2 per ton. This expense includes all the cost of cultivation, harvesting, and transportation.

It is not necessary to dwell upon the fact that with cane produced at such a cost, even the island of Cuba could not compete with Florida in the production of sugar. There is practically no other body of land in the world which presents such remarkable possibilities of development as the muck lands bordering the southern shores of Lake Okeechobee. With a depth of soil averaging, perhaps, 8 feet, and an extent of nearly half a million acres, with a surface almost absolutely level, it affords promise of development which reaches beyond the limits of prophecy.

THE CONSTITUTION OF THE MUCK SOILS.

Preliminary examinations of the muck lands of Florida have been made by Mr. D. C. Sutton, of the Department of Agriculture, assistant in charge of the experiment station at Runnymede. Three samples of the soil were taken by him, of which No. 1 was from the oldest cultivated land on the estate of the Florida Sugar Manufacturing Company's station, about 4 miles from the experimental field at Runnymede. Soil No. 2 was from a portion of the field which had been in cultivation for only a short time. No. 3 was taken from a spot further back, on the lands of the same company near the prairies. The results of the analyses are given in the following table:

	No. 1.	No. 2.	No. 3.
Insoluble matter	23.21	21.45	40.80
Soluble silica	.02	.02	.08
Potash	.11	.10	.07
Soda	.17	.15	.10
Lime	.16	.16	.10
Magnesia	.01	.01	.007
Peroxide of iron, alumina	3.06	2.79	1.83
Phosphoric acid	.19	.16	.09
Sulphuric acid	.01	.01	.01
Organic matter	68.11	70.52	53.65
Carbonic acid, chlorine, and loss	4.95	4.63	3.263
	100.00	100.00	100.00

These analyses were made before the establishment of the experiment station at Runnymede. On the establishment of this station it was deemed advisable to make a more complete analysis of the soils from the station itself. For this purpose, four samples of soil were taken, two of them from the station and two from old cultivated land, in order to determine the degree of change which would take place during cultivation. The two samples which were taken from the station are shown.

Sample No. 1 was taken from the front part of the station, near the cypress grove. Sample No. 2 was taken from the back part of the station land, near the pine land. These two samples show the two distinctive characters of the muck. The first sample is a muck of a brown color which drains easily and is very porous. No. 2 is a muck of a deep black color, more compact, and less easily drained. Sample No. 3 was taken from the orchard of the St. Cloud plantation, about 4 miles from the station, from a portion of land which, at present, is planted in grapes and has been in cultivation for five years, principally in vegetables. Sample No. 4 was taken from a field on the St. Cloud plantation which has been in cultivation in cane for five years.

In samples 1 and 2 is shown a complete section of the soil from the top and the sand below. Samples 3 and 4 were purposely taken from

the surface in order to show the effect of cultivation and oxidation on the character of the soil.

FLORIDA SOILS.

[Dried at 110°.]

	Carbon.	Hydrogen.	Volatile.	Absorption.	Nitrogen.
Soil No. 1.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
8976, first foot	57.67	4.48	90.60	145.14	2.24
8977, second foot	47.07	5.15	72.00	108.50	1.40
8978, third foot	8.52	0.53	15.00	46.68	0.31
Soil No. 2.					
8979, first foot	56.21	6.08	91.70	151.15	2.33
8980, second foot	58.57	6.04	96.50	188.32	2.83
8981, third foot	48.27	6.34	96.76	156.98	2.33
8982, fourth foot	21.72	2.03	40.88	81.05	0.95
Soil No. 3.					
8983	18.72	2.72	45.60	114.03	1.26
Soil No. 4.					
8984	19.48	2.69	45.70	167.95	1.18

The above figures show the composition of the soil in layers of 1 foot. Sample No. 1 had a depth of 3 feet, but the last foot was largely mixed with sand, as is shown by the decrease in carbon, hydrogen, nitrogen, and absorptive power, and the increase in mineral or nonvolatile matter.

Under the column "absorption" is given the percentage of water which the perfectly dry soils will absorb. It is seen that the pure muck, where unmixed with sand, will absorb more than its own weight of water, in one case almost double its weight. The importance of this property in times of drought and in relation to subirrigation must not be overlooked. The quantity of nitrogen in the layer of muck immediately above the sand is much less than in other parts of the soil, but this is not due to any impoverishment of the muck itself, but to the great admixture of sand. In the dry muck which has not been cultivated the value of the nitrogen reaches in one case $10.19 per ton, estimating nitrogen at 18 cents a pound. Cultivation for a few years reduces the percentage of nitrogen in the surface soils, as is indicated by the numbers obtained with samples 3 and 4.

NATURAL PHOSPHATE DEPOSITS.

The number of inquiries received by the Department of Agriculture, and submitted to the Division of Chemistry for answer, on the question of natural phosphates, has been greater than in any preceding year. The number of these inquiries will doubtless continue to increase, unless some information can be transmitted to those intending to send them in regard to the data which are on record in this office concerning these deposits.

No examination of natural phosphate deposits has been made by the Division of Chemistry nor by any division of the Department. Inquiries in regard to the extent and nature of phosphatic deposits should be sent to the Director of the Geological Survey, Bureau of Mineral Statistics.

In regard to the extent and character of the Florida phosphate deposits there may be cited a work by Francis Wyatt, entitled "The

Phosphates of America," published by the Scientific Publishing Company of New York.

For general information in regard to the Florida deposits, it may be said that they extend from Taylor and Madison counties, in the northern part of the State, southward and southeastward beyond Citrus County, forming a strip from 120 to 150 miles in length, with an average width of about 20 miles. It must be stated, however, that the exact extent of these deposits has not yet been determined; new deposits are discovered continually, and old ones are found to be of larger extent than supposed.

In regard to pebble phosphates, which were supposed to exist only in the Peace River, they have now been found in the Caloosahatchee, and dredging for these pebbles is already in progress above the town of Fort Myers. This would seem to indicate that the head waters of the Caloosahatchee also pass through phosphate deposits, and they have not yet been explored.

According to Prof. E. T. Cox, the beds of phosphate are not continuous, but are interrupted by protruding masses of underlying Eocene rocks. The Florida phosphates exist in two forms: first, what is called the rock phosphate, which exists in beds or layers and is mined like ordinary stone; and second, pebble phosphate, consisting of pebbles or phosphatic materials which have been disintegrated by the action of water and are found lying in the beds of streams. This stratum of pebble formation, where it has been cut by the streams, is said to be from 3 to 30 feet in thickness. In some localities the pebbles form fully 50 per cent of the whole mass, and the soft clay matrix in which they are embedded contains a high percentage of phosphoric acid. The composition of the best qualities of Florida phosphate is indicated by the following analyses of typical samples. In these samples Nos. 8879, 8881, and 8882 are samples of rock phosphate and number 8880 pebble phosphate:

Sample No. 8879.

Probable form of occurrence:	Per cent.	Estimated as—	Per cent.
Calcium fluoride	3.06	Calcium oxide	49.93
Calcium carbonate	8.45	Ferric oxide	0.60
Tricalcium phosphate	79.36	Aluminic oxide	2.03
Magnesium phosphate	0.59	Magnesium oxide	0.27
Aluminum phosphate	1.67	Phosphoric anhydride	37.65
Aluminum silicate	3.70	Water at 100°	0.24
Silica	0.38	Silica	2.74
Ferric oxide	0.60	Fluorine	1.49
Water at 100°	0.24	Carbonic dioxide	3.72
Organic matter and fixed water	2.17	Organic matter and fixed water	2.17
	100.22		100.84
		Less oxygen equivalent to fluorine	.63
			100.21

Sample No. 8880.

Probable form of combination:	Per cent.	Estimated as—	Per cent.
Calcium carbonate	14.59	Calcium oxide	52.42
Tricalcium phosphate	83.50	Ferric oxide	0.40
Magnesium phosphate	0.33	Aluminic oxide	0.67
Magnesium oxide	0.42	Magnesium oxide	0.57
Aluminic oxide	0.67	Phosphoric anhydride	38.42
Ferric oxide	0.40	Water at 100°	0.34
Water at 100°	0.34	Carbonic dioxide	6.44
	100.25		100.27

Sample No. 8881.

Probable form of combination:	Per cent.
Calcium fluoride	1.48
Calcium carbonate	18.71
Tricalcium phosphate	71.86
Magnesium phosphate	0.60
Aluminum phosphate	4.66
Aluminic oxide	0.16
Silica	0.49
Ferric oxide	1.19
Water at 100°	0.99
Organic matter and fixed water	0.77
	100.31
Less oxygen equivalent to fluorine	.16
	100.15

Estimated as—	Per cent.
Calcium oxide	49.86
Ferric oxide	1.19
Aluminic oxide	2.11
Magnesium oxide	0.28
Silica	0.49
Phosphoric anhydride	35.67
Fluorine	0.72
Water at 100°	0.99
Carbonic dioxide	8.23
Organic matter and fixed water	0.77
	100.31
Less oxygen for fluorine	.16
	100.15

Sample No. 8882.

(Partial analysis.)

Estimated as—	Per cent.
Calcium oxide	41.65
Ferric oxide	1.60
Aluminic oxide	3.38
Magnesium oxide	0.38
Phosphoric anhydride	30.18
Water at 100°	0.37
Loss on ignition	8.60

In connection with Florida phosphates, an interesting question has arisen concerning the method of applying them as fertilizers. Florida phosphates are more easily disintegrated, softer, and apparently in better condition to be assimilated by plants than almost any other natural phosphate known. This physical condition has led to experiments looking to the use of such phosphates as fertilizers without previous treatment with sulphuric acid. As is well known, most mineral phosphates are first treated with sulphuric acid in order to set the phosphoric acid free before being used for fertilizing purposes. On the other hand, the phosphate of lime which exists in bone, as is well known, is readily assimilated by plants without any previous treatment. The same is true of the phosphoric acid existing in the basic slags, a waste product in the manufacture of steel by the basic process.

Florida phosphates have been used, during the present year, to a considerable extent, directly applied to the soil without previous treatment with sulphuric acid, and the results are said to be favorable. It will be understood, however, that a single year's trial would not be sufficient to determine this fact. The matter, however, is of sufficient importance to deserve further investigation. If it should prove true that these phosphates are equally valuable without previous treatment with sulphuric acid, it will enable them to be delivered to the farmers at a much less price per ton than superphosphates could possibly be furnished. The whole of the expense of the sulphuric acid needed in the treatment, and the cost of the treatment, would be saved. During the coming year, experiments will be inaugurated on the sugar experiment station at Runnymede, Fla., with this purpose in view.

It may be well to say that this property, if it should prove to be a property, of Florida phosphates seems to be in opposition to the general views of agriculturists and chemists concerning the use of phosphates. With the exception of the cases noticed, which will be further discussed below, it

is the general opinion of scientific agriculturists that mineral phosphates at least require to be previously treated with sulphuric acid in order to produce any beneficial effect upon the crop. This is true, at least of any immediate beneficial effect, since it is recognized that sooner or later even the most refractory phosphates would be decomposed under the combined influence of meteorological causes and plant growth, and the phosphoric acid which they contain be rendered assimilable. If, therefore, the plant could have plenty of time, there is no doubt of the fact that it would gradually consume the phosphatic ration which was fed to it. This, however, is not what agriculturists want. While they are perfectly willing to fertilize a field for its value in the future, they do not want their reward postponed too long. The farmer wants a result the very first year of the application of the fertilizer and, therefore, at the present time, his mineral phosphate must be previously treated with sulphuric acid. If the Florida phosphates should prove an exception to this rule, it would be a great benefit to agriculture and would permit the free use of many phosphates now rejected by manufacturers of superphosphates on account of their high content of iron and alumina.

USE OF BASIC SLAG AS A FERTILIZER.

In the manufacture of steel by the basic process, so called, the ore from which the steel is made is treated in the furnace with an excess of lime, by means of which the phosphoric acid which it contains is almost entirely separated, and passes into combination with the lime as a tetracalcium phosphate. Ordinary mineral phosphates and the phosphate in bones, on the other hand, have a chemical composition known as tricalcium phosphate. The phosphates of the basic slag, therefore, have one more atom of lime to the molecule than the ordinary mineral phosphates and bone phosphates.

For several years, experiments have been carried on which have finally demonstrated beyond any reasonable doubt that the phosphoric acid in basic slags is available for plant food without previous treatment with sulphuric acid for the formation of superphosphates, as is done with natural phosphates. It will be seen by noticing the analyses which follow that the treatment of basic slags with sulphuric acid would be a very expensive one. Not only would the sulphuric acid be compelled to unite with the lime, which is already in union with the phosphoric acid, but in addition to this, large quantities of it would be consumed in combining with the lime, in a free state in these slags, and with a large amount of iron which they contain. This would not only cause a great expense in the use of sulphuric acid, but would also convert the iron into the form of green vitriol or ferrous sulphate, in which condition it might prove injurious to some plants when applied in large quantities; although when applied in the usual proportions of fertilizers it probably would have no injurious effect.

The slags coming from the furnaces are of two kinds; one being simply a mass of slag material without definite crystalline form, and the second having a definite crystalline structure. The chemical composition of the two forms varies chiefly in the fact that the crystalline slags are particularly free from excess of lime and iron, although the phosphate of lime which they contain exists in the same form as it does in the slags in general.

Two forms of crystalline slags have been examined in the Division of Chemistry during the present year, one containing acicular crystals and

the other tabular crystals. The composition of these two forms of crystals will be seen from the following table of analysis:

	Acicular crystals.	Tabular crystals.
	Per cent.	*Per cent.*
Calcium oxide	42.69	53.61
Ferric oxide	20.98	9.64
Aluminic oxide	3.71	.91
Magnesia	.49	.08
Vanadium dioxide	.18	....
Phosphoric anhydride	27.06	33.92
Silica	4.96	1.75
Total	100.07	99.91

The study of the crystals of the tetrabasic calcium phosphate is not new in chemical literature. Several years ago artificial crystals were prepared and analyzed. Observations on the grouping of the crystals in the slag tend to show that the first crystals to appear are the tabular ones. After these come the brown hexagonal needles, and the deeply colored, lustrous forms appear to come last of all.

The appearance of vanadium, a very rare element, in the slags would go to show that it is present in the ores from which they are made. Although vanadium is a rare and valuable element, its occurrence in this small quantity would probably not prove of any commercial value. The chief use of vanadium is in the application of its salts in dyeing. It helps to form very fast colors with certain forms of dyes.

Within a year or two the industry of furnishing basic slag as commercial fertilizers in this country has assumed large proportions. For many years the steel works in this country have been dumping their slags, under the impression that they were valueless. On account of their being easily pulverized, and from the fact that the phosphoric acid which they contain is so readily assimilable, they have, however, obtained a considerable value within a year or two.

These slags, when properly prepared, are now sold on the market for from $15 to $17 per ton, containing from 20 per cent to 25 per cent of phosphoric acid. It must not be forgotten that these slags probably act in a beneficial way apart from their mere content of phosphoric acid. The lime which they contain appears to be in excellent condition for producing a proper flocculation of the soils. The application, therefore, of basic slag to stiff, clayey soils would doubtless prove highly beneficial aside from their content of phosphoric acid. Thus, in the application of this fertilizer, we find a double benefit; first, the improvement which it makes in the physical condition of the soil, and second the amount of plant food available in it.

Before leaving this subject, it is deemed appropriate, in view of its importance and of the widespread interest existing in regard to it as shown by the numerous inquiries received at this office asking for information on the subject, and in view, also, of the lack of definite information regarding the character and value of these phosphate lands to which reference has been made, to earnestly recommend that this division be empowered to thoroughly investigate the subject, with special reference to the availability and value of these phosphate deposits to the agricultural interests of the country. Information has been received that large investments in these phosphate lands have been made by European, principally British, capitalists, and, as the time will certainly come when agriculture will be more dependent in this country upon artificial

fertilizers than at present, it would seem eminently desirable that this Department should be in a position to impart definite information to our people in regard to our own resources in the way of available fertilizing material.

A PROMISING BUTTER ADULTERANT.

Mr. H. J. Fish, superintendent of the Producers' Dairy Company, 324 B street SW., Washington, D. C., brought to me a sample of genuine butter, together with a sample of artificial butter, prepared by taking equal parts, by weight, of the genuine butter and milk and churning them together with the addition of a small quantity of the substance known as "gilt-edge butter compound," from the Planet Manufacturing Company, of Wichita, Kans. The directions for the use of this compound are to take a pint of fresh unskimmed milk and as much of the compound as you can heap on a silver 10-cent piece, and thoroughly mix the compound and milk together in the churn with as much salt as is necessary to salt 1 pound of butter. Add to this 1 pound of soft butter, and churn until the whole mass has come to butter, when you will have 2 pounds of butter and no milk. It is directed that the genuine butter should not be melted but made very soft and pliable so that the churn dasher will easily go through it. The milk should be warmed to the temperature at which it is taken from the cow. The churn should always be scalded or warmed sufficiently to prevent chilling the milk, plenty of salt added, and butter color, if used, before churning. It is particularly enjoined that the butter should not be worked, but should be made into rolls and put into jars and set away in a cool place to harden.

The sample of genuine dairy butter which was furnished with the compound was found to contain—

	Per cent.
Water	15.92
Butter fat	80.53
Ash	0.38
Curd and undetermined	3.17

This represents a fair sample of butter, with the exception that the water is a little higher than the average. In the premium butters obtained at the Chicago Dairy Show in 1889, the percentage of moisture varied in ten samples from 8.69 per cent to 11.86 per cent.

The artificial butter prepared from the above by the Producers' Dairy Company was subjected to analysis, and the following numbers were obtained:

	Per cent.
Water	49.55
Butter fat	45.45
Ash	1.34
Curd and undetermined	3.66

There was no doubt at all that the gilt-edge butter compound would do what was claimed for it, inasmuch as Mr. Fish had made the butter himself according to the directions.

The compound was also submitted to a practical test in the laboratory of this Department, and it was found that with 1 pound of butter, 1 pint of milk, and about 1 gram of the butter compound, 2 pounds of material could easily be made which resembled very closely a first-class article of butter, except that it was considerably softer.

It was at once suspected that the compound contained some emulsifying substance, either of a mineral nature or some organic ferment.

On subjecting the butter compound to analysis it was found to contain 70.48 per cent of anhydrous sodium sulphate and 29.52 per cent of organic matter. This organic matter responded perfectly to the test for pepsin, and it is undoubtedly pepsin; whether a pure pepsin or a crude form was not determined. Having established the fact that this is pepsin, experiments were made with pepsin and other digestive ferments, viz, pancreatin and trypsin. These bodies act as pepsin, and produce an emulsion which enables butter to incorporate an equal weight of milk in its substance without materially altering its appearance. The experiments were also tried with rennet, and it was found to act in the same way; whence it may be concluded that all the digestive ferments, when beaten up with milk and butter in the manner indicated, will produce an emulsion apparently causing the milk to entirely disappear.

The gilt-edge butter compound is colored pink, with some organic coloring matter in order to obscure its real nature. The anhydrous sodium sulphate seems to be added simply as a carrying material, and it is not supposed to produce any active effect in the emulsifying process; in fact, pepsin, pancreatin, trypsin, and rennet used without anhydrous sodium sulphate produce exactly the same emulsifying effect as the gilt-edge butter compound.

By this simple device the unprincipled dealer could easily impose upon his customers, furnishing them with an article of butter containing only half of the portion of that substance without greatly diminishing its price. The keeping properties, of course, of the emulsified butter would not be so great, but for rapid home consumption this would not be noticed.

MEAT PRESERVATIVES.

To determine the extent to which preservatives are added to canned meats an investigation has been carried on with certain meat preparations with the following results:

The preservatives which have been used in canned meats are: (1) Salt; (2) nitrate of potash; (3) sulphurous acid; (4) boric acid; (5) benzoic acid; (6) salicylic acid; (7) saccharin; (8) hydronaphthol. Fluosilicates are said to be used on rare occasions, but owing to the small chance of their presence, they are not included in the scheme.

The number of bodies used for this purpose has been gradually increasing with the demand, and with this increase in numbers comes a great increase in the difficulties of detecting and separating them. The search for preservative agents will soon come to be one of the most important operations in the examination of canned and preserved goods of all sorts.

SALT.

Salt seems to be the body generally used for the preservation of the so-called concentrated foods; such preparations as Liebig's extract of beef, Armour's beef extract, and many others containing 20 per cent of it, and sometimes even more. Ordinary potted meats contain it to the extent of from 1 per cent to 4 per cent. Salt is best detected in the ash. It has been the custom in making this determination to char the meat, extract with water, burn residual carbon to ash, add aqueous extract and evaporate. Salt is easily detected in the soluble ash, either by adding silver nitrate or by examining for cubical crystals which should deposit as the solution evaporates.

Potassium nitrate (niter, saltpeter) is used principally in the preservation of fresh meat. Meat is generally painted with a strong solution of it and then subjected to transportation.

Nitric acid may be tested for in several ways: (1) By making a Kjeldahl nitrogen determination, using the modification for nitrates; (2) by treating the meat with water (in the case of preparations containing much fat, preferably after extraction with ether) and testing the solution so obtained for nitric acid by one of the usual methods. It may also be detected by the formation of picric acid, as follows:

Phenol sulphonic acid is prepared by dissolving 1 part of phenol in 5 or 6 parts of strong sulphuric acid and diluting with an equal volume of water. The solution containing nitric acid is evaporated to dryness in a porcelain or platinum dish, and 1 or 2 cubic centimeters of the phenol sulphonic acid added; it is warmed gently, cooled, water added, followed by an excess of ammonia, when the well-known yellow color of ammonium picrate will make its appearance should nitric acid be present.

This salt (*i. e.*, nitrate of potash), in doses of from 1 to 2 ounces per diem, acts as a sedative on the circulation; in much larger doses it acts as a poison.

SULPHUROUS ACID.

When used as a preservative, sulphurous acid generally occurs in combination with calcium, sodium, or ammonium, in the form of sulphites or bisulphites. It is used in connection with some other preservatives to form many of the mixtures now on the market under fancy titles. Its use as a preservative has been prohibited in many countries.

The only reliable test for sulphurous acid in foods seems to be distillation in a current of carbon dioxide, and the collection of the acid in the distillate by appropriate means. Oxidation to sulphuric acid by means of iodine is used for this purpose with final precipitation as barium sulphate.

The gas is received in a solution of iodine in potassium iodide, acidulated with hydrochloric acid, and contained in a flask or beaker. Heat is applied to the flask and the distillation continued for half an hour. If sulphurous acid is present, it will be oxidized to sulphuric acid by the iodine, and may be precipitated by barium chloride as barium sulphate.

Dr. Forster reports a case of poisoning by "meat preserve," calcium sulphite, in SO_2.

BORIC ACID.

It is used principally in the form of its sodium salt, borax ($Na_2B_4O_7$). The most reliable information about the physiological action of boric acid seems to point to its comparatively harmless character, though authorities differ widely on this point. However, in spite of this, most countries have prohibited its use as a food preservative. Endemann says boric acid is a preservative of fresh meat only. The following passage regarding its preservative properties is taken from Thorpe's Dictionary:

E. le Cyon states that meat preserved by borax is not diminished in nourishing properties and that it is more readily assimilated, whereas Le Bon asserts that meat so preserved is useless as a food. T. Forster concludes that the use of boric acid in preserving food is of questionable value, as it increases the secretion of bile and the excretion of albuminous matters. Gruber likewise states that the decomposition of albumen in animals is increased by borax. Vigier, on the contrary, concludes from a series of experiments on dogs and men, that borax has no injurious effects even in large doses.

The four preceding preservatives are sometimes added singly to foods, but there are many mixtures of two or more of them on the market

under fancy titles. The following mixtures have been analyzed by E. Polenske: Ammonium sulphite; sulphurous acid; soda; borax crystallized; boric acid; salt; sodium sulphate; sodium sulphite; potassium nitrate; sulphite of lime; water.

Fresh meat is painted or injected with these. Some contain a trace of an aniline red dye, added, perhaps, to resemble blood.

BENZOIC ACID.

The most delicate test yet published for benzoic acid is that proposed by Mohler. Quantities of less than one-half a milligram may be easily detected by it in the absence of interfering bodies. It depends upon the formation of ammonium-meta-di-amido benzoate of a peculiar reddish brown color. The residue from an ether extraction is treated with 2 or 3 cubic centimeters of strong sulphuric acid and heated until fumes of the acid appear. Organic matter is charred and benzoic acid changed into sulpho-benzoic acid. A few crystals of potassium nitrate are added; the carbonaceous matter is first oxidized, and afterwards meta-dinitro benzoic acid formed. When cool, the acid is poured into water and ammonia added in excess, followed by a drop or two of ammonium sulphide, which causes the reduction to ammonium-meta-diamido benzoate, after first having passed through ammonium nitro-amido benzoate. Benzoic acid must be first separated in a state of approximate purity before this test can be made. Fats extracted from a beef tongue with ether (the tongue being known to be free from antiseptics) treated as above gave a color reaction which closely resembled that given by benzoic acid. This reaction is given by saccharin, hydronaphthol, β-naphthol, but not salicylic acid.

Benzoic acid is said to possess antiseptic properties greatly superior to salicylic acid, and, moreover, unlike salicylic acid, it is quite as active in the form of a salt. It is added to foods also because the methods for its detection are not so delicate and simple as in the case of salicylic acid. Benzoic acid acts as an irritant to the alimentary mucous membrane.

C. Ruche has found a very delicate test for albuminoids by the use of benzoic aldehyde. The test is applied as follows:

> The albuminoid, either solid or in solution, is treated with a considerable quantity of strong hydrochloric acid, a few drops of ferric chloride added, followed by a few drops of a dilute alcholic solution of benzoic aldehyde. In a short time an intense blue color is developed. The reaction is prompted by heat. By using a bit of the white of a hard-boiled egg, as the source of albumen, it is possible to detect so small a quantity as two or three tenths of a milligram of benzoic aldehyde. In this case the edges of the piece of egg are tinged blue.

An endeavor has been made to apply this test to the detection of benzoic acid after first effecting its reduction to benzoic aldehyde, but no one has been able to perform the reduction satisfactorily. Salicylic aldehyde gives the same reaction, though it does not seem to be so sensitive.

SALICYLIC ACID (ORTHO-HYDROXY-BENZOIC ACID).

When an aqueous solution of salicylic acid is treated with ferric chloride a beautiful purple color results. This reaction is very delicate, and plainly indicates the presence of 1 part of salicylic acid in 100,000 parts of water. The color is destroyed by alkalis and acids. It is not, however, peculiar to salicylic acid. It is a reaction common to many members of the phenol group, and is given by phenol, the cresotic acids,

resorcinol, salicylic aldehyde, and some others. However, this reaction is more delicate in the case of salicylic acid, and there is little chance, for the present, at least, of any of these bodies being added to food stuffs.

Its isomers, meta and para hydroxy benzoic acids, are without antiseptic properties. Griffiths describes its use as a cure for phthisis:

> When given in doses just sufficient to manifest its presence, symptoms closely resembling those of cinchonism result. These are fullness of the head, with roaring and buzzing in the ears. After larger doses, to these symptoms are added distress in the head or positive headache, disturbances of hearing and vision (deafness, amblyopia, partial blindness) and excessive sweating.

Salicylic acid in the form of its sodium salt is a popular remedy for rheumatism. It has to be given with care, however, on account of its strong action on the heart. There are actually cases of poisoning by it on record.

It is used largely to preserve articles of food and is especially popular for beer and wines. Its use as a preservative has been prohibited in most countries.

SACCHARIN (BENZOYL SULPHURIC IMIDE).

Saccharin is a white powder, slightly volatile at 100° and melting at 200° C. It does not distill over with steam. Soluble in 1,000 parts of cold water and 100 parts hot. Its most characteristic property is its intensely sweet taste, which is variously stated as being from 130 to 300 times sweeter than cane sugar, and is perceptible in 10,000 parts of water. It forms salts in which the hydrogen atom of the imide group is replaced by metals. It is said to be uninjurious, and when taken internally passes unchanged through the system into the urine. It is largely used as a substitute for sugar in diabetes and as a preservative for such substances as its sweet taste will permit.

According to Salkowski, commercial saccharin is liable to contain ortho-sulpho-benzoic acid and para-sulphamido-benzoic acid.

When a solution of saccharin in caustic potash is evaporated and the residue heated to 250° C., salicylic acid is formed, and may be tested for with ferric chloride after neutralization. This test is quite delicate, but has the disadvantage of being inapplicable in the presence of salycylic acid.

When saccharin is heated with a few drops of strong sulphuric acid and a slight excess of resorcinol, the mixture becomes first yellow, then red, and finally dark green, with the evolution of fumes of sulphur dioxide, and a body closely resembling fluorescein is formed. The heating should be repeated two or three times. Then, after cooling, water is added, followed by an alkali in excess, which gives a red solution exhibiting a strong green fluorescence. It is claimed for this test that it will detect one part of saccharin in several million parts of solution. Unfortunately, the test is not characteristic of saccharin, for both salicylic and benzoic acids give equally fluorescent solutions. In the case of benzoic acid it is possible that the body formed is benzylfluoresceine.

Advantage may be taken of the fact that saccharin contains sulphur. By heating it with sodium hydrate and nitrate, extracting with water, and aciduating, sulphuric acid may be thrown down with barium chloride. Little definite is known about its physiological properties.

Its use as a food preservative has been prohibited in France, Germany, and Belgium.

HYDRONAPHTHOL.

The composition of this body seems to be doubtful. It is stated by Griffiths that "hydronaphthol is the di-hydroxy-naphthalene of the chemist;" at least this is the case with the article manufactured by Messrs. Seabury & Johnson, London. It is also stated by Beebe that hydronaphthol is but a trade name for β-naphthol. In order to determine at least whether hydronaphthol is a mono or di-hydroxy-naphthaline, a sample of Seabury & Johnson's make was recrystallized from water, carefully dried, and the carbon and hydrogen estimated in it by combustion with copper oxide, with the following results:

	Hydronaphthol.	Theory for—	
		$C_{10}H_7(OH)$.	$C_{10}H_6(OH)_2$.
Carbon	84.74	83.33	75.00
Hydrogen	5.22	5.55	5.00

These results, in connection with the great similarity in crystalline form between β-naphthol and hydronaphthol, would seem to be sufficient to prove that it is β-naphthol. It must be remembered that no special precautions were taken in the preparation of the sample for analysis, and also that while standing awaiting the combustion it had assumed a distinct reddish-brown tinge; otherwise it might have agreed more closely with theory.

It is a white crystalline powder, which partially turns brown on standing, of a faint tarry odor. Its physical properties resemble those of β-naphthol. It is soluble in 2 parts of alcohol, 2 of ether, 300 of hot water, 1,100 of cold, and also readily in alkaline solutions. It is readily volatile with steam, and may also be distilled from its ammoniacal solution and in small quantities from its solution in caustic soda. It is said to be a great germicide, perfectly harmless, and an excellent antiseptic dressing for wounds. β-naphthol has been injected hypodermically without bad effects. It has been introduced into the stomach of a rabbit to the extent of 3.8 grams without producing death; the fatal dose for man would then be about 250 grams. Regarding the physiological properties of hydronaphthol, we have been able to find very little on record.

When hydronaphthol is acted on with strong nitric acid and the resulting nitro compound treated with potassium cyanide and warmed on the water bath, an isopurpurate of a deep red color is formed, resembling exactly that produced when picric acid is treated in the same way. This reaction is given by some other bodies, and is therefore not characteristic.

When hydronaphthol is dissolved in very dilute ammonia, rendered feebly acid with dilute nitric acid, and a drop of a solution of potassium nitrite added, a beautiful rose-red solution is obtained. The solutions must be cold, and the ammonia and acid so dilute that no appreciable amount of heat will be evolved during neutralization, otherwise the delicacy of the test will be greatly impaired. It will detect 1 part of hydronaphthol in 10,000 parts of water. This test is not given by any of the other preservatives.

The popular impression that preservatives are uniformly added to canned meats is doubtless erroneous. In thirty samples which have been carefully examined only two were found which had been treated with preservatives. One of these contained benzoic acid and the other hydronaphthol.

TEA, COFFEE, AND COCOA PREPARATIONS, AND THEIR ADULTERATIONS.

Tea, coffee, and cocoa preparations have received considerable attention in the investigation of foods by the Division of Chemistry. The enormous consumption of the beverages bearing these names is sufficient to tempt the unscrupulous dealers, and consequently the markets are flooded with spurious or adulterated coffees and cocoas, but probably with few teas which in the strict use of the word can be considered adulterated. As will be shown by this report, the practice of adding foreign leaves to the teas sold in this country does not seem to exist and teas are remarkably free from adulteration. Coffees and cocoas, on the contrary, are very frequently adulterated.

TEA—GENERAL CLASSIFICATION.

The substitution of teas of one grade for those of another can be practiced with impunity unless the samples are submitted to an expert. It requires one skilled in such matters to sort and "taste" teas.

METHOD OF MANUFACTURE.

The methods of preparing teas differ in the different countries in which this commodity is grown. In India the manufacturing processes are very simple, black teas only being produced. The method of preparing "black teas" consists essentially in withering the leaves by exposure to the sun or fire ; after withering they are rolled and twisted. The rolled leaves are subjected to a fermentation, after which they are dried—a process termed "firing."

In the manufacture of "green teas" the leaves are steamed or heated over a charcoal fire, then rolled and dried. The same plant furnishes the leaves for either black or green tea, the differences being due solely to the methods of curing.

The following table giving analyses by Kozai, of the Japan Imperial College of Agriculture, indicates the effect of the different methods of curing the leaves of the tea plant. The percentages are referred to the dry matter:

	Original leaves.	Green tea.	Black tea.
Crude protein	37.33	37.43	38.90
Crude fiber	10.44	10.06	10.07
Ethereal extract	6.49	5.52	5.82
Other nitrogen-free extract	27.86	31.43	35.39
Ash	4.97	4.92	4.93
Theine	3.30	3.20	3.30
Tannin	12.91	10.64	4.89
Soluble in hot water	50.97	53.74	47.23
Total nitrogen	5.97	5.89	6.22
Albuminoid nitrogen	4.10	3.94	4.11
Theine nitrogen	0.96	0.93	0.96
Amido nitrogen	0.91	1.13	1.16

According to these analyses there is a diminution in the tannin in both the green and black teas, but especially in the latter. The "other nitrogen-free extract" increased at the expense of the tannin. The theine remains practically constant. This diminution in the tannin is probably one of the reasons why the greatest consumers of tea, the English, consider black more wholesome than green tea.

THE ADULTERATIONS OF TEAS.

The adulterations of tea consist in (1) facing, (2) the addition of spent or partially exhausted leaves, (3) the addition of foreign leaves, and (4) the addition of foreign astringents and substances designed to affect the apparent quality or strength.

The process termed "facing," consisting in treating the leaves with certain pigments for the purpose of improving their appearance, should be considered an adulteration, since this treatment always has a fraudulent intent. These facing agents sometimes, it is claimed, amount to a considerable percentage of the weight of the tea. There is little evidence that the coloring matters employed are poisonous or in any way injurious to health. Spent or partially exhausted leaves are employed as an adulterant. Such leaves are rerolled, dried, and colored before mixing with genuine teas. These leaves are difficult of detection. Foreign leaves are also sometimes employed in the adulteration of teas. The genuine leaves may be distinguished from the foreign by their characteristic structure. A tea that is deficient in strength for any cause, especially through the addition of exhausted leaves, is sometimes treated with an astringent, such as catechu. The object of the catechu is to replace the tannin removed in brewing the tea, or to make up for a natural deficiency in strength.

An adulterated tea may contain gypsum, soapstone, or other mineral matter. These substances are added with the facing materials. Sulphate of iron is said to be sometimes added to teas to deepen the color of the infusion.

This list covers the principal adulterants of teas. Among others which have been mentioned by various writers are metallic iron, sand, particles of brick, etc. Certain green teas are popularly supposed to derive their color from contact with copper plates in drying or curing. There is no analytical evidence to prove that copper in any form has been employed for this purpose. A large number of teas have been examined both in the Division of Chemistry, and in other laboratories, without in a single instance detecting even a trace of copper.

SUMMARY OF THE RESULTS OF AN EXAMINATION OF TEAS BOUGHT ON THE OPEN MARKET.

The sixty-three samples which were examined in the course of these investigations were bought in stores of all grades. The samples represent teas of all prices, from the lowest to the highest. Many of the samples were of very inferior quality, but neither the chemical nor microscopical data give positive evidence of the addition of spent or foreign leaves. The ease with which foreign leaves can be separated from tea leaves precludes the possibility of any such having escaped detection. It is possible, though not probable, that spent leaves may have been added to a few of the teas.

A Canadian official chemist found two teas containing foreign leaves. A more recent report from the same laboratory, upon examination of fifty-eight teas, states that not a single foreign leaf was found.

Dr. Jesse P. Battershall, as reported in his work on food adulteration, examined nearly 2,000 samples of tea, and found foreign leaves present in but few instances. These samples were selected to meet the requirements of the United States tea adulteration act, which compels an inspection of all teas arriving at our ports, and, further, that adulterated teas shall be exported or destroyed. The samples examined were classed as doubtful by the inspectors. The evidence of these analysts, together

with the results of the work of this Department, indicate that our markets are practically free from teas containing foreign leaves.

Many of the teas examined contained frayed leaves; this was not confined to the cheaper grades, but even the highest priced often contained such leaves. There was no positive evidence of the admixture of spent tea, though in some instances the frayed leaves rendered the samples somewhat doubtful.

A large number of samples were heavily faced. Facing should be condemned on account of its use in making inferior teas appear to be of a superior grade. This practice also enables the admixture of spent leaves with little fear of detection. Faced teas can not be excluded from this country under the terms of the United States tea adulteration act.

The analytical and other work in connection with this report indicate that there are few if any spurious teas on the market. The range in quality is undoubtedly great, many samples deserving the name "tea" simply because they have been prepared from the leaves of the *thea*, and not through the many pleasant qualities which we usually associate with the beverage of this name. With the strict enforcement of the United States tea adulteration act the consumer is reasonably well protected so far as securing the genuine leaf is concerned, but of course has no protection from the sale of practically worthless teas.

COFFEE.

Coffees are very frequently adulterated and to a very considerable extent. In the investigations of the Division of Chemistry a large number of coffees have been examined, and certain classes have usually been found to be adulterated.

Genuine coffee is prepared from the seeds of the *Coffea arabica*. Various substitutes have been prepared by manufacturers for the purpose of cheapening the cost of this beverage and defrauding the consumers. In the manufacture of these so-called substitutes, and in the adulteration of genuine coffees, chicory, cereals, and acorns occupy a prominent place. Few of these substances have even little in common with coffee, and possess none of the valuable properties of the latter.

About 60 per cent of the coffee consumed in this country is imported from Brazil. The relative sizes of coffee beans is shown in the following table by Thorpe:

Number of seeds in a measure holding 50 grams of water.

Fine brown Java	187
Fine Mysore	198
Fine Neilherry	203
Costa Rica	203
Good ordinary Guatemala	207
Good La Guayra	210
Good average Santos	213
Fine long-berry Mocha	217
Good ordinary Java	223
Fine Ceylon plantation	225
Good average Rio	236
Medium plantation (Ceylon)	238
Manilla	248
Ordinary Mocha	270
West African	313

As may be seen from this table, Brazil coffees (average Rio) consist of rather small beans. In general, the values of coffees vary inversely as the size of the beans. Mocha is usually considered the best coffee of

commerce. It is stated that East India coffees are sometimes shipped to Arabia, and exported from this latter country as genuine Mocha. The seeds of the Mocha are small and dark yellow.

Java coffee, when new, is a pale yellow, and is then cheaper than when old and brown. This color is partly a result of the method of curing in addition to the effects of age. The high price of Java has led to the coloring of cheaper grades with certain pigments in imitation of this favorite coffee. It may be well to state that this practice can not be general, since no foreign coloring matters were found in the Javas examined in the course of the investigations made in connection with this report, though it is probable that coffees colored by exposure to a high moist heat may have escaped detection.

THE ADULTERATIONS OF COFFEES.

Chicory, leguminous seeds, and cereals are the principal adulterants. Many persons prefer coffee containing an admixture of chicory.

FACING OR COLORING.

Inferior or damaged coffees are frequently treated by some process for the improvement of their appearance and in imitation of superior grades. Java seems to be especially subject to this treatment. South American coffees are often exposed to a high moist heat, which changes their color from green to brown, thus forming imitation Java. The following pigments may be used: Scheele's green, yellow ocher, Silesian blue, chrome yellow, burnt umber, Venetian red, drop black, charcoal, and French black.

CHICORY.

Chicory is prepared from the root of the *Cychorium intybus*. This substance is easily detected by the microscope. Roasted chicory will sink in cold water, leaving a trail of color behind it. Chicory itself is frequently adulterated with other roots or with cereals or leguminous seeds.

CEREALS, LEGUMINOUS SEEDS, AND ACORNS.

Judging from the investigations made, chicory is not as frequently employed as an adulterant as cereals, peas, beans, acorns, etc. These substances are in general detected by the presence of starch, and are finally identified by their structure as shown by the microscope.

MISCELLANEOUS ADULTERANTS OF COFFEES.

The following substances are reported as being sometimes employed in the adulteration of coffees: Canna seed, sawdust, oak bark, and baked liver. They are detected by the microscope.

COFFEE SUBSTITUTES.

A number of substitutes have been proposed for coffee. Many of these have little claim to be entitled substitutes, since they simply furnish a decoction more or less bitter and of a coffee color. Besides chicory, Mogdod coffee (seeds of *Cassia occidentalis*), Mussænda coffee (supposed to be the seeds of *Mussænda borbonica*), acorns, figs, leguminous seeds, burned sweet potatoes, and cereals have been employed as coffee substitutes.

Coffee substitutes should always be sold in packages bearing a dis-

tinctive label, and when mixed with genuine coffee, the percentage of each substance should be stated.

ARTIFICIAL COFFEES.

Within two or three years the coffee markets have been presented with so-called artificial coffees. The first official action toward suppressing this fraud in this country was probably that taken by the health officers of New Jersey.

Reports from dealers in various parts of the country indicate that the sale of artificial coffees has become very general. These "coffees" are usually manufactured in imitation of genuine coffee, and as far as regards color and shape would usually escape detection by the consumer.

The following is a list of the artificial coffees examined, together with a description and statement of their probable composition:

Serial No. 8766. Coffee, bran, and molasses, roasted but not molded.

8767. Bran and molasses, roasted but not molded. Samples, numbers 8766 and 8767, were obtained through the courtesy of Dr. J. N. Hurty, chemist, Indianapolis, Ind.

8491. Imitation coffee beans, roasted. Composed principally of wheat flour.

8859. Imitation coffee beans, roasted. Composition: Wheat flour, coffee, and chicory.

8883. A rather poor imitation of roasted coffee beans. Imported from Germany as "Kunst Kaffee." This sample was obtained from the customs authorities. A number of samples of Kunst Kaffee have been obtained from different sources. Composition: Wheat flour, chicory, pea or bean flour, and probably nut shells. Caffein has been reported in Kunst Kaffee and was supposed to have been derived from Kola nuts. This imitation coffee is wholesaled to mixers at about 11 cents per pound

8884. Imitation roasted coffee beans. Composition: Wheat flour, coffee, and chicory.

8885. Imitation green coffee. This sample contains two kinds of "berries," one containing wheat flour and and the other wheat flour and coffee. There were no indications of mineral coloring matter.

8951. "Coffee pellets," molded, but not in the form of coffee beans. When mixed with ground and probably with whole coffee these so-called "pellets" would probably escape the notice of the purchaser. Composition: Wheat flour, ground bran, and probably rye. Sold at 5½ or 6 cents per pound in 100-barrel lots.

8952 and 8953. Same composition and manufacture as No. 8951, differing only in color and shape.

8954. Ground artificial coffee. Composition: Chicory, leguminous seeds (peas or beans), wheat, barley, and fragments of buckwheat.

8955. Imitation roasted coffee beans. Composition: Wheat flour.

8956. Two kinds of imitation roasted coffee beans, one consisting of wheat flour and the other of wheat flour and woody tissue, probably sawdust.

8957. Imitation roasted coffee beans. Composition: Wheat flour. Selling price, 11½ cents per pound.

8958. Granular artificial coffee. Composition: Hulls of leguminous seeds, probably peas, formed into granules with molasses, then roasted.

8996. Sample marked "Coffee substitute, Columbia AAA." Composition: Bran and molasses formed into small lumps and roasted.

According to recent information, a factory has been seized in France which manufactured an artificial coffee of the following composition: Chicory, 15 kilograms; flour, 35 kilograms; and sulphate of iron, 500 grams. This, as may be seen, is far from being an innocuous mixture.

The *Kunst Kaffee* (serial No. 8883), imported from Germany, pays a

duty of 2 cents per pound as a coffee substitute. It seems strange that an article whose very form is suggestive of fraud should be admitted under any circumstances at our custom-houses.

Wheat flour and bran mixed with molasses seem to be the favorite materials for the manufacture of imitation coffees. It is hardly to be expected that the manufacturers would select a good quality of flour, but probably they employ damaged or worthless flour, refuse biscuit, and the waste of the bakeries.

The sample numbered 8954 apparently contains mill sweepings, judging from the number of cereals employed.

A large number of ground coffees have also been examined. A large proportion of these samples were grossly adulterated.

There is reason to believe that the retailer is often an innocent party to the fraud. In one instance artificial coffee was found in a sample obtained from one of the most reputable grocers in Washington. A large number of samples were afterwards purchased from this grocer, all of which were free from adulterants of any kind. On investigation the roaster proved to be the guilty party. Pure coffee was delivered to the roaster, and he, after appropriating a portion of this coffee, made up the deficiency with the artificial article, returning a mixture to the dealer.

The limits of this abstract will not permit a more extended review of the adulteration of coffee; suffice it to say, that all coffee preparations, as well as whole and ground coffees, are subject to sophistication. Samples of the so-called "coffee extracts" have been examined which did not contain a particle of genuine coffee. Fortunately the adulterants of coffee can easily be detected.

The practice of adulterating coffees is widespread, and the consumer has little if any protection, not even always the honesty of his grocer, since the latter is also liable to be deceived.

COCOA AND COCOA PREPARATIONS.

The raw material from which the cocoas and chocolates of commerce are manufactured is the "cocoa bean," the seed of the cocoa, or cacao, tree (*Theobroma cacao*). While this tree has been successfully introduced into various warm countries, tropical America, its native land, still furnishes the larger and more highly valued portion of the world's supply of cocoa. The tree is 20 to 40 feet in height, blooms continuously, and yields two crops a year. The seeds are embedded in a fleshy fruit resembling a cucumber; when first removed they are colorless, fleshy, and covered with mucilage; on drying, with exposure to air and light, they become golden yellow to red brown in color and hard and brittle in texture. They are egg-shaped, somewhat compressed, one-half to three-quarters of an inch long and one-quarter of an inch broad.

After removal from the fruit two processes are used for the preparation of the seeds for market. For the preparation of "unfermented cocoa" they are freed from adhering pulp and at once dried in the sun. For the production of "fermented cocoa" the beans are placed in piles in sheds or are buried in trenches and allowed to ferment for a time before being completely dried in the sun. When buried the beans are placed in casks or other coverings; hence the earthy coating is no longer a mark for determining which process has been used. Much of the acridity and bitterness disappears in this process of fermentation. The beans so prepared have a mildly oleaginous, pleasant, slightly bitter taste, are more or less aromatic, and are greatly preferred to the unfermented beans for the manufacture of chocolate, etc. The value of

the product is largely dependent on the care bestowed on this operation. Considerable loss occurs in the subsequent processes of sifting, hand picking, roasting, and removal of husks. The total losses are from 16.76 per cent to 25.78 per cent, with a mean of 22.11 per cent. The roasting serves to facilitate the removal of the husks, and to develop the aroma and flavor.

On account of the peculiar properties of the cocoa bean, its preparations merit a place on our tables for two reasons. In addition to being, like tea and coffee, the material for the preparation of a pleasant and exhilarating beverage, it is a valuable food material; not only is it much richer in nutritive substances than tea or coffee, but both the soluble and insoluble portions become a part of the beverage, while only the constituents soluble in hot water are obtained in the beverages prepared from tea and coffee. The food value of cocoa preparations has, however, been greatly overestimated, and many of the present modes of preparation do not develop in the highest degree possible the pleasing aroma and flavor. The inventive energy of many manufacturers seems to be spent on the production of a supposed highly nutritive and easily digestible preparation; the valuable fat is removed and the delicious aroma and flavor destroyed by chemicals for the ostensible purpose of rendering more digestible a residue of doubtful food value.

The more important constituents of the husked cocoa bean are fat, theobromin, the nonalkaloidal nitrogenous substances, starch, the coloring matter called cocoa-red, and the mineral matter.

The fat, cocoa or cacao butter, in consequence of its quality and peculiar excellence, is unquestionably the constituent of the cocoa bean possessing the highest food value. It usually forms 45 per cent to 55 per cent of the husked bean, rarely falls below 45 per cent, and only one recent analysis shows as low as 36 per cent. At ordinary temperatures it is white or slightly yellowish, having a pleasing taste and odor, and showing but little tendency to become rancid. Its melting point being below the temperature of the body, insures its being presented in liquid form to the action of the digestive juices. The low melting point, the little tendency to become rancid, and other properties, render cocoa butter peculiarly suitable for the basis of many pharmaceutical preparations. This by-product of the manufacture of cocoa preparations has, therefore, a well-established place in commerce.

Theobromin, the alkaloid of cocoa, is very closely related chemically to caffein, the alkaloid of tea and coffee, and has similar effects on the system, the power possessed by the beverages prepared from these substances "to cheer and not inebriate" being largely due to the presence of these alkaloids. Separated from the bean, it is a white powder, permanent in air, crystallizable in microscopic needles, and having a bitter taste. The husked bean contains 1.28 per cent to 2.40 per cent of theobromin and the husk 0.42 per cent to 1.11 per cent. Its unimportance commercially at present offers no temptation to remove it from cocoa preparations before placing them on the market. Small percentages of caffein have been found in cocoa beans and somewhat larger percentages in the husk.

The nitrogenous nonalkaloidal portions of the cocoa bean belong to several classes. They amount in all to from 12 to 20 per cent of the entire substance. About one-half of these bodies are digestible. Their food value has doubtless been much overestimated.

Cocoa contains 5.78 per cent to 15.13 per cent of starch. It occurs in small well-characterized grains that are not easily confused with other starches when examined microscopically.

Cocoa-red, the coloring matter of the bean, seems to be related to the tannin or astringent principle also present, but authorities differ as to whether it is a decomposition product of a tannin, or whether a tannin is the result of its decomposition.

Small percentages of a gum and of tartaric acid have been reported. The aroma of cocoa is considered to be due to the presence of minute quantities of an aromatic volatile oil.

The preparations of cocoa are so numerous that more or less confusion of terms naturally arises. Most American manufacturers prepare a plain chocolate (known in Europe as cacao-masse), made by reducing the roasted and husked beans to a paste and pressing into form of cakes. When this is combined with much or little sugar (generally much), vanilla, and spices, the various "sweet," "vanilla sweet," "vanilla," "spiced," etc., chocolates are produced. These are also usually met in the form of cakes, but are sometimes pulverized and sold as "powdered" chocolates. The high percentage of fat renders a permanent powder impossible without its partial removal or the addition of some diluent, as sugar, starch, or flour. The preparations in powder known as "cocoas," "bromas," etc., are prepared in accordance with one or the other, or a combination of these methods.

Cocoa husks are offered on the market in bulk and in packages, but their use seems to be quite limited at present.

Perhaps no food material offers conditions so favorable for profitable adulteration and so well utilized by its manufacturers as do cocoa preparations. There is probably no more misleading or more abused term in the English language than "soluble cocoa." No cocoa in the market contains more than 10 per cent to 30 per cent of matter soluble in water unless the material so dissolved is foreign soluble material that has been added during the process of preparation. The term seems to be used to denote a preparation that allows none of the insoluble matter to deposit from the beverage prepared from it. This purpose may be accomplished in two ways; the material may be so finely divided that a very long time will be required for its deposition, or foreign substances (as starch or sugar) may be added to render the liquid of so high specific gravity or so pasty that the insoluble matter will not deposit. The first method is decidedly to be preferred; it accomplishes the object in view and puts the preparation in better condition for the action of the digestive juices, and all this without the addition of a cheap diluent that is always at hand in every kitchen should its use be desired. Any additions of this kind should be considered adulteration unless their nature and quantity are accurately stated.

Attempts at the preparation of easily "digestible cocoas" (preparations to which pepsin or other digestive ferments have been added do not come in question here, since the favorable condition of the preparation is not involved, but the supplying of a deficiency in the strength of the digestive juices) seem to fail in purpose and to be attended with the introduction of objectionable substances. The use of alkalis for this purpose is quite generally regarded as injurious to health, and the effect is the opposite of that desired.

The removal of the fat is not considered an adulteration when it is acknowledged, and it is undoubtedly desirable for persons with weak digestion. It seems important, however, that the public have a means of knowing accurately to what extent it has been removed. It also seems desirable that the percentage of sugar be accurately stated. The adulterants added are reported to be, besides starches and sugar, substances of organic and inorganic origin to increase the weight and

bulk, ferruginous and other pigments to restore the color of highly diluted preparations, and foreign fats to restore the normal percentage of fat, or to give the preparation the plasticity required for molding. The husk, because of its coarse nature and consequent tendency to act as an irritating substance in the alimentary canal, and in consequence of its poverty in the constituents that render cocoa valuable, is regarded as an adulterant when not removed, or when added to increase the weight or bulk of the preparation.

Sixty-two samples of cocoa preparations have been submitted to microscopical and chemical examination in the laboratory of the Department of Agriculture. A brief summary of the results of these investigations is presented in the following table:

Number of samples.	Character of samples.	Number of samples containing large additions of starch or flour.	Number of samples containing very large amounts of cocoa husks.	Number of samples containing sugar.			
				20 to 30 per cent.	44.7 per cent.	50 to 60 per cent.	60 to 71.9 per cent.
6	Plain chocolates	4	....	....	....	....	....
29	Sweet chocolates	11	8	....	....	21	8
27	Cocoas, bromas, etc	12	6	7	1	3	....
62	Totals	27	14	7	1	24	8

For further details concerning the adulterations of tea, coffee, and chocolate, reference is made to Bulletin 13 of the Division of Chemistry, part VII (in press), which contains the full work of which the foregoing is a brief extract.